Part I

Introduction

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Excerpt
More information

1 Genesis

> What does an embryo resemble when it is in the bowels of its mother? Folded writing tablets. Its hands rest on its two temples respectively, its two elbows on its two legs and its two heels against its buttocks . . . A light burns above its head and it looks and sees from one end of the world to the other, as it is said, then his lamp shined above my head, and by His light I walked through darkness (Job XXIX, 3) . . . It is also taught all the Torah from beginning to end, for it is said, And he taught me, and said unto me: "Let thy heart hold fast my words, keep my commandments and live" (Prov. IV, 4) . . . As soon as it sees the light, an angel approaches, slaps it on its mouth and causes it to forget all the Torah completely . . .
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> (*Babylonian Talmud: Tractate Niddah, folio 30b* "Niddah," 1947)

Of the various aspects of human nature, the biology of our knowledge systems is an area we struggle to grasp. The possibility that our knowledge might be predetermined by our organic makeup is something we find difficult to accept. This is not because we resist our condition as biological organisms – living breathing bodies whose design is shaped by natural laws and evolution. We rarely give a second thought to our lack of fur or our inability to fly and swim underwater. We are not even disturbed by many obvious shortcomings of our mental faculties – our inability to perceive infrared light, the fallibility of our memory, and the haphazard fleeting character of our attention. Those fickle quirks of our neural machinery are surely inconvenient, but they rarely leave us pondering the confinements of our fate.

Inborn knowledge systems, however, are a whole different matter. Inborn knowledge systems are biologically determined frameworks of knowledge. The animal literature presents countless examples of partly inborn knowledge systems, ranging from birdsong and ape calls to the amazing ability of bees to recruit an inborn code in communicating the location of the nectar to their sisters, and the astonishing capacity of the Indigo Bunting to find its navigational path guided by the stars and the earth's magnetic field (Gallistel, 2007; Hauser, 1996). But when it comes to our own species, such inborn frameworks of knowledge raise many difficulties (Pinker, 2002). Inborn knowledge systems constrain our capacity to recognize ourselves and grasp the world around us.

Their existence implies that there are truths we are bound to hold and others we are destined to expunge. Some of us might find these confinements too disturbing to accept. Others suggest that innate truths are privileges of which we, humans, are not worthy. Subsequent discussions of the cited Talmudic passage indeed explain that it is the stubborn refusal of the embryo to leave the womb that forced the angel to slap her face, thereby causing her to forget her inborn knowledge of the Torah (Tanhuma, Exodus, Pekudei, III). But regardless of whether innate knowledge is a burden we are bound to carry or a precious gift that we are morally unfit to embrace, the prospective of such knowledge systems is unsettling.

And yet, modern cognitive science suggests that, like their animal counterparts, human infants come to the world equipped with several systems of rudimentary knowledge. While no mortal is born knowing the Bible or the Koran, infants seem to have basic knowledge of physics, math, biology, psychology, and even morality. They know, for example, that objects are cohesive entities that can only move by contact (Carey, 2009; Spelke, 1994), and they have a rudimentary concept of number that allows them to distinguish two from three objects (for example Feigenson et al., 2002). Young children also understand that, unlike artifacts, living things have an essence that is immutable even when their appearance is changed (Keil, 1986), that humans are agents that have thoughts and beliefs of their own (Onishi & Baillargeon, 2005), and they distinguish between agents with benevolent intentions and those with sinister goals (Hamlin et al., 2007). While the content of such knowledge systems is quite coarse, these systems nonetheless fix our early grasp of the world and pave the road for all subsequent learning.

Of the various candidates for inborn knowledge systems, language has a central role (Chomsky, 1957; 1972; Pinker, 1994). Much research suggests that the capacity for language is not only universal to humans but also unique to us. But the nature of our language mechanisms remains controversial. Moreover, the debate concerning the origins of language has focused almost exclusively on a single aspect of our linguistic competence – our capacity to structure words into sentences (Jackendoff, 2002). The narrow focus on syntax does not do full justice to our linguistic ability. One of the most striking features of human languages is that they all include two distinct levels of organization (Hockett, 1960). One level is the patterning of words to form sentences. A second, less familiar, level, however, generates words (meaningful elements) from patterns of meaningless elements, typically sounds. It is this second level that is the topic of this book.

When we consider our own language, it is usually meaning, rather than sound patterns, that first catches our attention. But think of yourself hearing spoken announcements in a foreign airport, or stumbling upon a foreign-language clip on YouTube, and the pattern of sounds will immediately become apparent. Even if you speak neither French, Russian, nor Arabic, you can still tell these languages are different from each other. Perhaps you can even guess what they are. And since you cannot do so by tracking the syntactic structure of the language or the contents of the conversations around you, the only clues available to you are linguistic sound patterns – the inventory of sounds that make up each language and the unique ways in which those sounds combine.

Every human language patterns words from meaningless elements. In spoken languages like English, those meaningless elements are sounds. The words *dog* and *god* for instance, comprise three sound elements – the vowel *o* and the two consonants, *d g*. Taken on its own, none of these elements carries a meaning, but together, these meaningless elements form words. And the difference between these two words stems only from the ordering of their sounds – their sound pattern. If you are an English speaker, you recognize that the sounds *d,o,g* are English sounds, whereas the *ch* of *chutzpa* isn't. English speakers also notice that patterns such as *dog* are typical of English words, unlike permutations such as *dgo*, which sound foreign. Being an English speaker entails knowledge about the sound structure of this language: its inventory of meaningless elements (sounds), and how these sounds pattern together. This knowledge is called phonology.

We humans are extremely good at tracking the phonological structure of our language. When an infant arrives into the world, language, in his or her mind, is a sound pattern. There are no sentences or words. Just sounds spoken by people – sounds and sound combinations. But linguistic sounds are special for infants. Newborn infants are preferentially tuned to the patterns of human speech (Vouloumanos & Werker, 2007; Vouloumanos et al., 2010). Moreover, newborns recognize the characteristic rhythm of their native language (e.g., French, which they have heard in the womb for several months) and distinguish it from foreign languages (e.g., Russian) even when spoken by the same bilingual talker (Mehler et al., 1988). They can pick up the abstract pattern in a speech-stream (e.g., the ABB pattern in *mokiki, ponini, solili*) after only a few minutes of exposure (Gervain et al., 2008) and automatically generalize it to novel items (e.g., *wafefe*). And by the time an infant reaches her first birthday, she becomes familiar with the particular sounds and sound combinations characteristic of her language (e.g., Jusczyk et al., 1994; Kuhl et al., 1992; Mattys et al., 1999; Saffran et al., 1996; Werker & Tees, 1984).

Why does every human language exhibit phonological patterns? Why are people so adept at weaving and tracking the sound structure of their language? And why do languages have the specific phonological patterns that they do?

For many people, laymen and experts alike, the answer is patent. The patterns we produce mimic the ones we hear. An English-learning infant produces words like *dog* rather than *perro* because this is what his or her English-speaking community says. And when further pressed to consider why language communities employ these particular sound patterns – *dog*, for English, rather than *dgo*, for instance – most people would shrug the "obvious" answer: *dog* is just easier to articulate. Together, such statements capture a widely held sentiment. Phonological patterns, in this view, are determined by the properties of our memory, ears, and mouths. Memory leads us to follow the patterns we have heard in the speech of people around us, and our ears and mouths favor certain patterns over others. Our skill at weaving phonological patterns stems from those generic abilities. Indeed, memory, audition, and motor control are not specific to language or humans. These same abilities allow us to track and memorize linguistic sound patterns much in the way we track any other configurations – visual motifs on wallpaper, patterns of sounds in our favorite musical piece, or the statistical trends in the stock market frenzy. Similarly, the aural and oral restrictions on linguistic sequences are indistinguishable from the ones shaping the perception of noises and music, or the aural command we exercise in kissing or chewing. In short, phonological patterns require no special linguistic talents. And to the extent our phonological patterns differ from those of other species, the difference can only reflect the anatomy of those shared mechanisms or their control.

While nonlinguistic pressures (e.g., memory, attention, auditory and motor limitations) undoubtedly influence the design of phonological patterns, these forces are not necessarily their makers. Memory, for instance, does not explain why it is that all human languages exhibit phonological patterns. A phonological system is indeed not logically mandatory for communication. Speakers could certainly convey concepts by holistic sounds: one sound (e.g., "a") for lion, and another "o" for eating, would suffice to generate sentences ("a o" for lions eat; "o a" for eating a lion, etc).

Memorization not only fails to explain why phonological patterning exists but also cannot account for the characteristics of attested patterns. Our phonological capacity is prolific and robust. We do not merely parrot the sound patterns we hear in our linguistic environment. Rather, we instinctively extend those patterns to new words that we have never heard before. And in rare cases where people have been raised deprived of any phonological system, they have been shown to spontaneously generate one on their own.

The most striking feature of phonological systems, however, is their unique, nearly universal design. Linguistic research has shown that the phonological systems attested across languages exhibit some common characteristics. These similarities in design are important because they imply a common pattern maker that imposes broad, perhaps universal restrictions on all languages (e.g., Jakobson, 1968; Prince & Smolensky, 1993/2004). These common restrictions, moreover, are reflected not only in statistical regularities across languages, but also in the behavior of individual speakers. Given two structural variants, such that one variant A is more "popular" across languages than the other, B, people will reliably prefer A to B even when neither occurs in their language (e.g., Jusczyk et al., 2002; Moreton, 2002). And when a new language is born, it eventually recapitulates the design of existing phonological systems (Sandler et al., 2011).

The shared design of phonological systems – existing and recently nascent – cannot be trivially explained by general principles of oral or aural patterning. First, like all correlations, the link between ease of articulation/perception and phonological structure is ambiguous. While certain patterns might be preferred because they are easier to produce and comprehend, the causal link could also go in the opposite direction: patterns might be easier to perceive and produce because they abide by the demands of the language system itself. And indeed, people's sense of articulatory ease greatly varies depending on their language. While English speakers find a sequence like *dgo* impossible to utter, Hebrew and Russian speakers produce it without blinking an eye, whereas Japanese speakers would stumble not only on the "exotic" *dgo* but even on the plain English *dog*. Phonological patterns, moreover, are not restricted to articulatory sequences. People extend their phonological sequences to the perception of language in either oral or printed rendition. In fact, phonological patterns are not even confined to aural language. Since phonology is the patterning of meaningless elements, phonological patterns can extend to the visual modality as well. Indeed, every known sign language manifests a phonological system that includes meaningless units of manual linguistic gestures, and, despite the different modalities, signed phonological systems share some important similarities with spoken language phonologies (Sandler, 2008). Phonological design, moreover, is not only quite general but arguably unique – it differs in significant ways from both other systems that use the auditory modality (i.e., music) and the auditory communication systems used by nonhuman animals (Jackendoff & Lerdahl, 2006; Pinker & Jackendoff, 2005).

My claim, to reiterate, is not that the properties of the communication channel – ears and mouths – are irrelevant to the design of phonological patterns. In fact, subsequent chapters show that the tailoring of the phonological mind to its preferred channel of communication – the aural/oral medium – is a critical feature of its adaptive design. But the fit between phonological patterns and their channel does not necessarily mean that the channel is itself the pattern-maker. Rather than weaving phonological patterns directly, the aural/oral channel could have shaped our phonological abilities in a nuanced oblique fashion.

Phonological design is indeed evident not only in our instinctive natural language but also in its encoding via writing, and its decoding, in reading. Unlike language, reading and writing are cultural inventions that are not invariably shared by every human society, just as the sciences of math and physics are not universal. But just as math and physics are founded on our rudimentary inborn systems of number and physics, so are our inventions reading and writing erected upon the phonological principles of our spoken language (DeFrancis, 1989; Perfetti, 1985).

(1) Some interesting properties of phonological patterns
- a. *Generality*: All established languages exhibit phonological patterns.
- b. *Generalization*: Phonological patterns are not confined to the memorization of familiar patterns.
  - (i) People generalize the patterns of their language to novel words.
  - (ii) Phonological systems reemerge spontaneously.
- c. *Design*: Phonological patterns manifest a shared design.
  - (i) The phonological patterns of different languages share a common design.
  - (ii) The design of phonological systems is partly shared across modalities – for signed and spoken language.
- d. *Uniqueness*: The design of phonological systems is potentially unique.
  - (i) It differs from the design of nonlinguistic auditory forms of communication.
  - (ii) It differs from the structure of auditory communication systems used by nonhuman species.
- e. *Scaffolding*: The design of the linguistic phonological system lays the foundation for the invention of reading and writing.

The generality of phonological patterns, their regenesis, their potentially universal, unique design and centrality to cultural inventions (summarized in 1) all suggest an instinctive capacity for phonology, supported by a specialized, partly inborn knowledge system. This book explores this possibility. Doing so will require that we take a closer look at what we mean, precisely, by "knowledge systems," "specialization," and "inborn." But before we consider the mental and brain mechanisms that support phonological patterning, it might be useful to first review some of the instinctive phonological talents of humans. Chapter 2 uses a rather broad brush to paint some of the most intriguing aspects of the phonological mind. Inasmuch as it is possible, this introduction separates the explanandum – the properties of phonological patterns – from the explanation, the mental system that generates them. Some accounts of this system are discussed in Chapter 3 and evaluated in subsequent chapters.

2 Instinctive phonology

Humans have some special phonological talents. We instinctively intuit that certain phonological patterns are preferred to others even if we have never heard them before, and we will weave phonological patterns regardless of whether our language uses oral speech or manual gestures. Phonological instincts are so robust that people spontaneously generate a whole phonological system anew, and when human cultures invent systems of reading and writing, they impose those patterns on their design. Phonological patterns, however, are not arbitrary: they conform to some recurrent principles of design. These principles are broadly shared across many languages, but they are quite distinct from those found in animal communication or music. This chapter documents those instinctive talents of our species, and in so doing, it lays down the foundation for discussing the architecture of the phonological system in subsequent chapters.

2.1 People possess knowledge of sound patterns

All human communities have natural languages that impose detailed, systematic restrictions on phonological patterns. Unlike traffic laws or the US Constitution, the restrictions on language structure, in general, and phonological patterning, specifically, are not known explicitly. Most people are not aware of those restrictions, and even when professional linguists desperately try to unveil them, these regularities are not readily patent to them. Yet, all healthy human beings know these restrictions tacitly – we encode them in our brain and mind and we religiously follow them in our everyday speech despite our inability to state them consciously. And indeed, we all have strong intuitions that certain sound structures are systematically preferable to others (see 1–3). For example, English speakers generally agree that *blog* is better-sounding than *lbog*; they prefer *apt* to *tpa*; they consider *came* as rhyming with *same* or even *rain* (indicated by ~), but not *ripe*; and they have precise intuitions on the parsing of words into smaller constituents. A frustrated motorist might refer to their noisy car exhaust as an *eg-freaking-zaust*, but not an *e-freaking-gzhaust* (a fact marked by the * sign, which conventionally indicates ill-formed linguistic structures).

(1) Syllable-structure intuitions
  a. blog *lbog
  b. apt *tpa, *pta
  c. apt *apd
  d. box, *bocz

(2) Rhyme
  a. came∼same
  b. came∼rain
  c. came≁ripe

(3) Parsing *exhaust*
  a. eg- freaking -zaust
  b. *e- freaking -gzaust

Not only do people have strong intuitions regarding the sound patterns of their language, but they also take steps to repair pattern-violators. Phonological repairs are usually too rapid and automatic to be noticed when applied to words in one's own language, but careful analyses demonstrate that repairs take place routinely. English speakers frequently talk about *keys*, *bees*, and *dogs* (pronouncing all *s*'s as *z*), but when it comes to *ducks*, they render the *s* sounding like *us*, not *buzz*. And when presented with novel singular nouns like *bokz* and *mukz* (with the *k* of *buck* and *z* of *buzz*, see 1d and 4c), these, too, are strange sounding (Mester & Ito, 1989). It thus appears that the plural suffix of *duck* should have been *z* (as in *dogs*), but the "badness" of the -*kz* sequence leads people to automatically adjust it to yield *ducks*.

And indeed, speakers tend to confuse illicit sound sequences with licit ones (e.g., Hallé et al., 1998; Massaro & Cohen, 1983). For example, when presented with the illicit *tla*, English speakers incorrectly report that they have heard a disyllabic form, the licit *tela* (Pitt, 1998). Similarly, Japanese speakers misidentify *ebzo* (with the syllable -*eb*, illicit in Japanese) as *ebuzo*, whereas speakers of French (which tolerates *eb*-type syllables) recognize it accurately (Dehaene-Lambertz et al., 2000; Dupoux et al., 1999; Dupoux et al., 2011; Jacquemot et al., 2003). The fact that such confusions are detected very early in life – at the age of 14 months (Mazuka et al., 2012) – and persist despite people's best efforts to distinguish between those forms all suggest that the errors are not the product of some prescriptive conventions. Rather, these linguistic illusions occur because we instinctively extend the phonological pattern of our language to all inputs, and when violators are detected, we automatically recode them as licit forms.

Phonological repairs are indeed readily noticeable when we hear nonnative speakers of our language. English speakers, for example, immediately notice