Language Sciences 60 (2017) 69–79

Contents lists available at ScienceDirect

Language Sciences

journal homepage: www.elsevier.com/locate/langsci

Feature economy vs. logical complexity in phonological pattern learning☆

Klaas T. Seinhorst

Amsterdam Center for Language and Communication, University of Amsterdam, Spuistraat 134, 1012 VB Amsterdam, The Netherlands

A R T I C L E   I N F O

Article history:
Available online 4 November 2016

Keywords:
Complexity
Acquisition
Phonological features
Regularisation
Learnability
Sign language

A B S T R A C T

Complexity has been linked to ease of learning. This article explores the roles of two measures of complexity – feature economy and logical complexity – in the acquisition of sets of signs, taken from a small sign language that serves as an analogue of plosive inventories in spoken language. In a learning experiment, participants acquired data sets that varied in feature economy and logical complexity. The results from this study suggest that ease of learning is best predicted by logical complexity, and that a considerable number of learners unintentionally reduce the complexity of their input.

1. Introduction

The contributions in this volume present various perspectives on the notion of complexity, illustrating the wide array of applications this term has in linguistics. Perhaps the most widely known example from phonology is found in the description of syllable structure, where onsets and codas are called complex if they contain more than one segment. However, many other interpretations are possible: Maddieson (2009), for instance, argues that a phonological alternation is more complex when it is less predictable. The present article focuses on two specific quantifications of complexity, namely feature economy and logical complexity (or incompressibility), and compares them as predictors for ease of learning in a phonological acquisition task.

The structure of this article is as follows: Section 2 discusses the possible role of complexity in phonological acquisition, and introduces the measures of feature economy and logical complexity; Section 3 describes the experimental stimuli and procedure; Section 4 presents the results; the conclusion and discussion form Section 5.

2. Complexity in the acquisition of feature combinations

Phonological segments are often regarded as bundles of features. For instance, the combination of [−continuant], [+bilabial] and [−voiced] describes the segment /p/, and only /p/. Such features are not merely useful descriptive tools, but they have psychological reality in the speaker-listener (a.o. Chládková, 2013). Features are commonly used to analyse the internal structure of phoneme inventories, both in spoken language and sign language. Pressures of articulatory/gestural ease and perceptual distinctiveness play a major role in the typology of such inventories (for spoken language: Passy, 1890; Martinet, 1955, 1968; Boersma, 1998; Boersma and Hamann, 2008; for sign language: Crasborn, 2001; Mathur and

☆ I'm greatly indebted to Paul Boersma and Silke Hamann for invaluable advice and fruitful discussion, to Dirk Jan Vet for technical assistance, to an anonymous reviewer for their excellent suggestions, and to all participants for their time and effort.

E-mail address: seinhorst@uva.nl.

http://dx.doi.org/10.1016/j.langsci.2016.10.002
0388-0001/

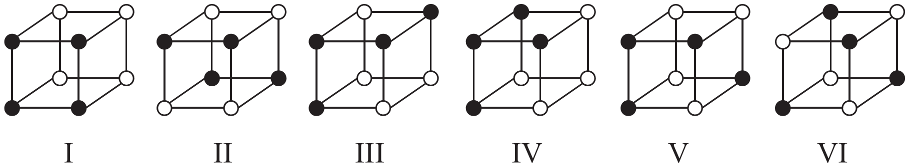

Fig. 1. The six category structures from Shepard et al. (1961).

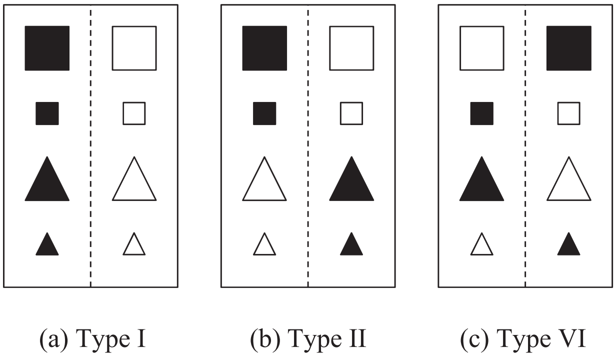

Fig. 2. Examples of stimulus divisions from different Shepard types.

Rathmann, 2001; Ann, 2008; Ormel et al., 2013), but cognitive constraints operate on the typology of phoneme inventories as well. For instance, it has often been noted that sound systems disprefer gaps; Martinet (1968) ascribes the sparsity of such systems to cognitive factors. In terms of feature economy – a principle stating that languages tend to maximally combine their phonological features (de Groot, 1931; Martinet, 1955; Clements, 2003, 2005) – Martinet would predict that more economical inventories are easier to learn; and what is easier to learn, is more likely to be cross-linguistically frequent (Kirby and Hurford, 2002; Christiansen and Chater, 2008; Chater and Christiansen, 2010).

2.1. *Learning of category structures: non-linguistic stimuli*

In experimental psychology, the learning of classes of feature combinations has been investigated since at least the early 1960s (a.o. Shepard et al., 1961; Nosofsky et al., 1994; Feldman, 2000). These experiments use a set of 8 stimuli whose properties are described in terms of three binary features. This data set can be divided into two mutually exclusive classes of 4 stimuli in different ways, all of which may be – through rotation and/or mirroring – reduced to one of six possible so-called category structures.[1] These are Types I–VI in Fig. 1. The stimuli that are included in a class are drawn as black circles, those that are not included as white circles.

The three features are represented in the three dimensions: they are binary because they can only take on two values (i.e. in the figure: front vs. back, left vs. right, top vs. bottom). Suppose that the features are shape (square vs. triangle), size (small vs. large) and colour (black vs. white). If the stimuli are divided according to Type I, this division could look like Fig 2a.; divisions of Types II and VI could look like Fig 2b and c respectively.

Shepard et al. (1961: 3) presume that higher Type numbers are more difficult to learn and remember. In order to classify stimuli from a Type I division as belonging to either the left class or the right one, two features can be disregarded: in the example shown in Fig. 2(a), shape and size are irrelevant. For the Type II division from Fig. 2(b), only size is irrelevant, and for Type VI divisions, none of the features can be ignored.

Shepard et al. carried out two experiments. In the first experiment, learners were shown the individual stimuli and replied to them with one of two response categories, after which they received feedback on their response. The experiment was completed when participants had given 32 consecutive correct responses. In the second experiment, subjects were asked to formulate the rules they thought underlay the division, and two weeks later were instructed to recreate the division from memory. The results of both experiments reflect the increasing difficulty of the six types: learners perform best on Type I category structures, worse on divisions of Type II, even more poorly on Types III–V, and worst on Type VI. For instance, many participants indicated that they had learned Type VI divisions by rote. In an experiment using the same six types, Griffiths et al. (2008) presented learners with three out of four stimuli from a class, then asked them to complete the set. In an iterated learning paradigm, they found that Type I became increasingly frequent over generations.

There are (at least) two ways of quantifying complexity in the Shepard types: we can compute their feature economy indices, and their logical complexities. Table 1 lists all feature economy indices *E*, using a computation similar to Hall (2007:

[1] I will speak of 'classes' rather than 'categories', because the latter term will later be used to refer to phonological categories.