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Default nominal inflection in Hebrew: evidence for mental variables

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Abstract

According to the 'word/rule' account, regular inflection is computed by a default, symbolic process, whereas irregular inflection is achieved by associative memory. Conversely, pattern-associator accounts attribute both regular and irregular inflection to an associative process. The acquisition of the default is ascribed to the asymmetry in the distribution of regular and irregular tokens. Irregular tokens tend to form tight, well-defined phonological clusters (e.g. *sing-sang*, *ring-rang*), whereas regular forms are diffusely distributed throughout the phonological space. This distributional asymmetry is necessary and sufficient for the acquisition of a regular default. Hebrew nominal inflection challenges this account. We demonstrate that Hebrew speakers use the regular masculine inflection as a default despite the overlap in the distribution of regular and irregular Hebrew masculine nouns. Specifically, Experiment 1 demonstrates that regular inflection is productively applied to novel nouns regardless of their similarity to existing regular nouns. In contrast, the inflection of irregular sounding nouns is strongly sensitive to their similarity to stored irregular tokens. Experiment 2 establishes the generality of the regular default for novel words that are phonologically idiosyncratic. Experiment 3 demonstrates that Hebrew speakers assign the default regular inflection to borrowings and names that are identical to existing irregular nouns. The existence of default inflection in Hebrew is incompatible with the distributional asymmetry hypothesis. Our findings also lend no support for a type-frequency account. The convergence of the circumstances triggering default inflection in Hebrew, German and English suggests that the capacity for default inflection may be general.

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1. Introduction

The study of inflectional morphology has been the subject of a fierce controversy between symbolic and associative theories of cognition. Common to both accounts is the proposal that irregular inflection (e.g. *go-went*, *mouse-mice*) is achieved by associative memory. The center of debate concerns regular inflection (e.g. *like-liked*, *house-houses*). According to the pattern-associator hypothesis[1], mental processes are fully explicable by the associations between specific tokens. Pattern-associator accounts (e.g. Rumelhart and McClelland, 1986; MacWhinney and Leinbach, 1991; Plunkett and Marchman, 1991; Daugherty and Seidenberg, 1992; Plunkett and Marchman, 1993; Hare and Elman, 1995; Hare et al., 1995), thus, attribute both regular and irregular inflection to an associative process. The representation of regular words is indistinguishable from irregular words. All words are represented solely by their phonological, semantic and orthographic features. Variables, such as noun or verb, are eliminated from mental representations. Regular inflection is thus largely explicable by the distribution of regular and irregular tokens in the language. Conversely, the 'word/rule' account (Pinker, 1991, 1994, 1997, 1999) views regular inflection as a symbolic process. Symbolic processes operate over variables and are blind to the contents of specific tokens (Fodor and Pylyshyn, 1988). Consequently, regular inflection applies across the board, regardless of the target's idiosyncratic features. In addition, regular inflection serves as a default: it applies to any target that fails to activate stored associations by the 'elsewhere condition'. An 'elsewhere condition' is the application of a general linguistic process upon the failure to trigger a more specific process (Kiparsky, 1973). The conditions for activating irregular inflection (e.g. '*go*' as a condition for '*went*') constitute a subset of the conditions for triggering regular inflection (e.g. the identification of *any* canonical verb stem). A failure to activate irregular inflection thus triggers the regular default.

There is substantial empirical support for the view of regular inflection as a default. For instance, regular inflection is assigned to borrowings, names and denominals, all failing to trigger stored associations due to their lack of a canonical root (Kim et al., 1991, 1994; Marcus et al., 1995). Likewise, regular inflection applies to non-words that are dissimilar to English verbs, hence, are unlikely to activate similar stored irregular tokens (Prasada and Pinker, 1993). In both cases, regular inflection applies generally, regardless of the similarity of the targets to stored tokens. Specifically, the assignment of regular inflection to non-words that are dissimilar to existing regular verbs does not differ from non-words that are highly similar to familiar regular verbs (Prasada and Pinker, 1993). Conversely, regular inflection is observed for borrowings, names and denominals that are highly

[1]We use the term 'pattern associator' to refer to the class of cognitive models that eliminate mental variables. Our criticism of the 'pattern-associator' hypothesis should not be equated with a criticism of connectionist formalism. As we next explain, connectionism is fully compatible with symbolic accounts of cognition. Likewise, the term 'pattern associator' does not refer to any specific type of connectionist models (e.g. feedforward networks). The pattern-associator hypothesis strictly concerns mental representations, not their implementations (for a similar distinction, see Pinker and Prince, 1988; Marcus et al., 1995; Marcus, 1998b, 1999).

similar, or even identical to stored irregular words (Kim et al., 1991, 1994; Marcus et al., 1995).

Despite the strong empirical support for the existence of a default inflection, controversy still remains regarding its source. According to the symbolic view, the wide variety of circumstances resulting in default inflection indicates that regular inflection operates over mental variables (Marcus, 1998a,b, 1999; Pinker and Prince, 1988). Variables are abstract labels. For instance, the variable 'verb stem' enumerates tokens such as *like*, *explain*, *refrigerate*. Variables define equivalence classes: they assign a uniform representation to all the tokens they enumerate, ignoring their individual idiosyncrasies. It is the uniform representation of all nouns (or verbs) by a single label that explains the generality of regular inflection and its insensitivity to token-specific features. Likewise, it is the representation of the grammatical category of a 'root' which explains the blocking of irregular inflection for denominals, names and borrowings, despite their strong resemblance to stored irregular tokens. The appeal to variables is thus fundamental to the symbolic account. In contrast, according to the pattern-associator view, variables play no role in cognitive processes. The emergence of a regular default may be adequately explained by an associative process (e.g. Rumelhart and McClelland, 1986; Seidenberg, 1987, 1997; Seidenberg and McClelland, 1989; Elman, 1993; Hare and Elman, 1995; Elman et al., 1996; Plaut et al., 1996; Rueckl et al., 1997).

The present research examines whether default inflection appeals to mental variables. We first review two associative explanations for the emergence of default inflection. We then present a new challenge to the associative account: Hebrew nominal inflection. We describe the distributional properties of Hebrew nouns and the predictions of the associative account regarding their inflection. The following experiments test these predictions.

1.1. Associative accounts of default inflection

Associative theories of cognition have proposed two accounts for the emergence of default inflection: the type frequency and the distributional asymmetry hypotheses. According to the *type-frequency* account (e.g. Rumelhart and McClelland, 1986; Plunkett and Marchman, 1991; Daugherty and Seidenberg, 1992; Plunkett and Marchman, 1993; Bybee, 1995), the role of regular inflection as a default is due to the ubiquity of regular types in the language. In modern English, for example, regular inflection applies to the majority of verbs in the language. Thus, the probability that a novel verb activates nodes shared with regular verbs is higher than the probability of it activating irregular verbs' nodes. The type-frequency hypothesis has been subject to theoretical and empirical challenges. On the theoretical end, it is unclear whether type frequency is sufficient for the acquisition of default inflection (see Prasada and Pinker, 1993; Marcus et al., 1995). Subsequent empirical findings indicated that type frequency is not necessary for default inflection either. Specifically, the documentation of default inflection in German (Clahsen et al., 1992; Marcus et al., 1995) and Old English (Hare et al., 1995), languages in which most types are irregular, demonstrates that default inflection may be acquired despite the

minority of regular types. Thus, type frequency is neither necessary nor sufficient for default inflection.

An alternative associative account attributes the acquisition of the default to the distribution of regular and irregular tokens. Hare et al. (1995) noted a contrast in the distribution of regular and irregular tokens in Old English. Irregular tokens tend to group in phonological clusters (e.g. *tiv-tav*, *dif-daf*, *dirf-darf*). These clusters occupy bounded, well-defined regions of the phonological space. In contrast, regular tokens are sparsely distributed throughout the remaining space. According to the *distributional asymmetry* account, the acquisition of default regular inflection is due to the asymmetry in the distribution of regular and irregular tokens. Furthermore, Hare et al. (1995) demonstrated that a regular default is successfully acquired by a connectionist network trained on a corpus modeled after Old English. Hare et al. attribute the learnability of the default to the distributional properties of Old English. Specifically, they note that:

> 'In the current simulations, there are two conditions which together are responsible for the emergence of the default category. First, the phonologically well-defined classes occupy bounded regions in the input space....Second, the default category itself must be represented by items which are spread throughout the remaining space. It is not necessary that this space be well-populated; in the current simulations, very few exemplars were required. What is necessary is that these examples serve to isolate the regions of attraction of the non-default categories (more precisely, they establish hyperplanes around those basins). The effect of both conditions is that the network learns, through a relatively few examples, that any item which does not resemble one of the five well-defined classes is to be treated in the same way. This is the 'elsewhere condition', which is often defined as the default (Hare et al., 1995, pp. 626–627).'

The success of the model of Hare et al. (1995) suggests that distributional asymmetry may be sufficient for the acquisition of default inflection by a connectionist network. However, the implications of these findings to symbolic accounts are not entirely clear. The success of a connectionist network in modeling the regular default does not necessarily challenge its view as a symbolic process. Indeed, symbolic and connectionist accounts of cognition are not mutually incompatible. Multilayer networks are universal function approximators (Hornik et al., 1989; Siegelman and Sontag, 1995), hence, the potential of *some* connectionist device to implement symbolic functions is virtually guaranteed (for discussions, see Marcus, 1998a,b). The debate between symbolic and connectionist accounts of cognition does not concern *whether* connectionist networks can adequately model cognition, but instead, *how* they do so.

At the heart of the debate is the role of variables in mental computations: are mental computations constrained by the combinatorial structure of variables, or is cognition largely explicable by the statistical distribution of tokens? Specifically, in the case of inflectional morphology, the disagreement concerns the representation of grammatical categories (e.g. a 'verb stem', 'noun stem' 'suffix') and rules, i.e.

mental functions that are sensitive to the combinatorial structure of these categories (e.g. 'copy the stem and add a suffix') (Marcus, 1998b, 1999). The successful acquisition of default inflection by a connectionist network is not incompatible with the representation of variables and rules. As pointed out by Marcus (1999), the model of Hare et al. (1995) implements rules and variables. This model includes two components: a feedforward network and an interactive-activation network that transforms the probabilistic phonological output of the feedforward network into discrete phonemes. In each of these components, there is a built-in distinction between the stem and *-ed* suffix. The feedforward network designates separate output units to the stem (with a further distinction between onset, nucleus and coda units) and the *-ed* suffix. Likewise, the clean-up network includes separate banks of units for the stem vowels and the inflected vowel and *-ed* suffix. This architecture implements two rules. One is 'copy the stem vowel', a rule implemented by innately fixing the weights of the connections between the nuclei in the base and inflected form to one. A second rule is 'add *-ed* if the memory trace for an irregular is weak'. The precedence of irregular over regular inflection (the 'elsewhere condition') is achieved by the innate inhibitory connections between the inflected nucleus and the regular suffix. Thus, if the feedforward component of the network strongly activates an inflected nucleus, then the regular suffix is inhibited. Conversely, the failure to locate an inflected (irregular) nucleus triggers regular inflection due to innately fixed excitation of the stem and regular suffix. Because the Hare et al. (1995) model has innate rules, it does not offer an *alternative* to the symbolic approach, nor does it demonstrate that default inflection can be acquired in the absence of variables.

A different perspective for evaluating the distributional asymmetry hypothesis would be to test it cross linguistically. On this hypothesis, languages manifesting a regular default must exhibit a contrast in the distribution of regular and irregular tokens in the phonological space. As noted by Plunkett and Nakisa (1997), this prediction clearly contrasts with the prediction of the symbolic account:

> 'The symbolic default assumes that for any language there will be a type of inflection which is rule-based – that is, a phonology-independent operation on a symbolic representation of the singular. The rule-based inflection is innately specified and so is universal to all languages whatever the statistical nature of their inflectional system. A neural network can also exhibit a default-like behavior given an appropriate distribution of input forms. A distributional default develops in a network when the 'default' class is distributed diffusely throughout the phonological space and the other classes are compact and separate (Plunkett and Nakisa, 1997, p. 833).'

Plunkett and Nakisa (1997) further explored the predictions of the distributional asymmetry account by examining nominal inflection in Arabic. To investigate the distributional properties of nominal Arabic plurals, Plunkett and Nakisa conducted a principal component analysis of nominal Arabic plurals, assessed the coherence of plural classes and the predicability of plural forms by class membership. Their findings provided no evidence for a distinction in the phonological clustering of sound ('regular') and broken ('irregular') Arabic plurals. Plunkett and Nakisa (1997)

did not examine empirical evidence for the existence of a default in Arabic. However, given the overlapping distributions of sound and broken plurals, they predicted that sound plurals in Arabic should not function as a default. Indeed, if the regular default was contingent on distributional asymmetry, then one should not expect to find a regular default in a language where the phonological properties of regular and irregular nouns or verbs are overlapping. Hebrew seems to challenge this prediction.

1.2. Nominal inflection in Hebrew

Hebrew plurals are produced by concatenating a suffix, either *-im* or *-ot* to the singular base. Morphological affixation often triggers also phonological changes to the base. Thus, to form the plural, speakers must determine the identity of the suffix and the phonological structure of the plural form.

The selection of the suffix is partly predicted by gender. Hebrew nouns are marked for gender, masculine or feminine. Most masculine nouns are inflected by adding the *-im* suffix to their base; feminine nouns are typically inflected using the *-ot* suffix (see Table 1). Thus, for masculine nouns, plurals taking the *-im* suffix are considered regular, whereas those taking the *-ot* suffix are irregular. Conversely, for feminine nouns, it is the *-ot* inflection that is regular (Aronoff, 1994). Despite the strong link between gender and inflection, this correspondence is not entirely consistent. Aronoff (1994) notes about 80 masculine nouns that are inflected by the *-ot* suffix, and about 30 feminine nouns inflected using the *-im* suffix. Furthermore, gender is not reliably inferred from the surface structure of the singular form, since some masculine-sounding nouns are feminine, taking *-ot* suffix. The only reliable cue for gender is syntactic agreement. In the absence of syntactic cues, the inference of gender and plural suffix is uncertain.

The inference of a noun's gender and plural suffix is somewhat easier for feminine nouns. Many singular feminine nouns are reliably marked for gender by feminine suffixes (e.g. *-et*: *mishkéfet, molédet, zaméret*; *-a*: *yaldá, morá, piná, bniyá, bakashá*). All nouns marked by these suffixes are feminine, and the majority of them take *-ot* as their plural suffix. In contrast, the gender of masculine nouns and their plural inflection is less obvious. The principal phonological cue for the gender of masculine nouns is the absence of a feminine suffix: most singular nouns lacking a feminine suffix are masculine. We thus refer to these nouns as 'masculine sounding'. Although most masculine-sounding nouns take the regular *-im* suffix, neither the gender of these nouns nor their plural suffix can be reliably determined from their surface form. Some

Table 1
An illustration of regular and irregular plurals of masculine and feminine nouns

Noun gender	Regular		Irregular	
Masculine	-IM		-OT	
	bul-bulím	*stamp*	zug-zugót	*pair*
Feminine	-OT		-IM	
	trumá-trumót	*contribution*	dvora-dvorím	*bee*

of the masculine sounding nouns are, in fact, feminine, and their inflection takes the *-ot* suffix (e.g. *?érets-?aratsót*, country). In addition, there is also a large set of masculine-sounding nouns that are indeed masculine, but their inflection is irregular, taking the *-ot* suffix (e.g. *zug-zugót*, pair). Thus, the plural suffix of masculine-sounding nouns cannot be reliably predicted from their phonological properties.

In addition to the task of selecting the plural suffix, Hebrew speakers must also determine the phonological structure of the plural. Inflection often triggers phonological changes to the singular form. Plural inflection reliably shifts the stress to the suffix. In addition, inflection often alters the stem's vowels. These phonological alternations are independent of the suffix chosen or gender (see Table 2). However, they are highly predictable by the phonological structure of the base, which, in turn, reflects its formation. Hebrew words are formed by inserting a root into a word pattern. Word patterns include place holders for the root consonants, and they provide the vowels and affixes. Nominal word patterns are called mishkalim (singular: mishkal). For instance, the words *kelev* (*dog*), *sheleg* (*snow*), and *degel* (*flag*) are formed by inserting their roots in the CeCeC mishkal. Because members of a given mishkal share their vowels and affixes, they are quite similar phonologically. The mishkal is also helpful in determining the phonological structure of the plural. All plurals generated for members of a given mishkal share the same phonological structure. For instance, all members of the CeCeC mishkal (e.g. *kélev*) are inflected as CCaC-suffix (e.g. *klavím*). The mishkal is thus an excellent predictor of the plural's phonological structure.

Given that the mishkal defines a phonological cluster of singular nouns and that it also reliably predicts the phonological structure of the plural stem, one may wonder

Table 2
An illustration of nouns that are phonologically changed versus unchanged in their plural form as a function of their gender and regularity

Regular		Irregular	
No stem alteration			
Masculine			
bul-bulím	(stamp)	zug-zugót	(pair)
kis-kisím	(pocket)	kir-kirót	(wall)
shiryón-shiryoním	(armor)	dimyón-dimyonót	(imagination)
Feminine			
trumá-trumót	(contribution)	dvorah-dvorím	(bee)
dirá-dirót	(apartment)		
Stem alteration			
Masculine			
kélev-klavím	(dog)	kéver-kvarót	(grave)
matós-metosím	(airplane)	malón-melonót	(hotel)
Feminine			
réfet-refatót	(cow shed)	dérex-draxím	(road)
gadér-gderót	(fence)		
yaldá-yeladót	(girl)		

whether the mishkal can also reduce the ambiguity regarding the selection of the plural suffix. Indeed, in some languages, phonological clustering is a strong cue for inflection. For instance, English irregular verbs cluster in phonological families that may be used to predict their inflectional class (regular vs. irregular) and phonological structure. If Hebrew inflection was organized in a similar fashion, then the strong phonological clustering of Hebrew nouns could have provided a powerful clue for inflection. Specifically, if members of the mishkal shared the same inflectional suffix, then speakers could have used the phonological properties of the mishkal in order to eliminate the ambiguity regarding the plural suffix. Unfortunately, however, the mishkal provides little help in identifying the suffix of masculine sounding nouns. For instance, the CaCáC mishkal includes 48 nouns whose gender is masculine and their plural form is CCaC-suffix. Forty-three of these nouns take the *-im* suffix (e.g. *zakan, beard*; *marak, soup*) whereas the remaining five (e.g. *zanav, tail*; *valad, newborn*) take the *-ot* suffix. Likewise, the mishkal CoC (e.g. *nof-, view*) contains 26 nouns whose gender is masculine and their plural form is CoC-suffix. Twelve of them take the *-im* inflection (e.g. *nof-nofim, view*; *xof-xofim, shore*) and 14 take the *-ot* suffix (*?or-?orot*, light; *sod-sodot*, secret). There appears to be no feature (phonological or semantic) that can be used to determine which member of a given mishkal is regular and which one is irregular, nor is there any feature that can discriminate between regular and irregular nouns across different mishkalim. As we demonstrate in the following analyses, the lack of a correspondence between phonological clustering and inflectional classes is not unique to the two mishkalim illustrated above, but is, instead, a typical property of masculine sounding nouns in Hebrew.

1.3. Does Hebrew exhibit an asymmetry in the distribution of regular and irregular masculine-sounding nouns?

The distributional-asymmetry hypothesis views default inflection as a consequence of the asymmetry in the distribution of regular and irregular nouns in the phonological space. Because of its templatic morphophonology, Hebrew is likely to exhibit phonological clusters which correspond to its nominal word patterns, the mishkalim. Members of a given mishkal share the same vowels, consonant suffixes and their arrangement relative to the root consonants. Furthermore, the mishkal is also the only predictor of the plural's phonological form. Thus, members of a given mishkal form a phonological cluster. However, the mishkal defines its members by their phonology, not their inflection. If phonology is a good predictor of inflection, then members of the phonological cluster defined by the mishkal would tend to agree in their inflection. According to the distributional-asymmetry hypothesis, Hebrew speakers could use such phonological clustering to acquire default inflection. Conversely, if the phonological clusters defined by the mishkal include both regular and irregular members, then Hebrew should not exhibit default inflection, according to the distributional hypothesis.

Our previous discussion identified two forms of regular inflection in Hebrew: the masculine regular suffix is *-im* and the feminine *-ot*. These two regular classes differ in the extent their plural members are predictable from the phonological form of the

singulars. Feminine nouns are reliably marked for gender by their phonology and their inflection is highly predictable. In contrast, for masculine nouns, both gender and inflectional suffix are uncertain. If phonological form is critical for inflection, then the acquisition of the default may be quite different for each of these forms. Indeed, Plunkett and Nakisa (1997) observed a similar contrast in the phonological coherence of feminine and masculine sound plurals in Arabic, a contrast that resulted in an inferior performance on masculine nouns in their simulation. Our present investigation focuses on the default inflection of masculine-sounding nouns for two reasons. First, the classification of masculine nouns as regular or irregular is clearer than that of feminine nouns.[2] Second, the inflection of masculine nouns appears to be far less predictable by their phonology. Thus, masculine-sounding nouns present a stronger test for the default inflection hypothesis.

To examine whether regular and irregular nouns contrast in their distribution in the phonological space, we examined the structure of 1971 masculine sounding nouns listed in a Hebrew grammar book (Goshen et al., 1970). Our database included 1778 masculine-sounding nouns whose plural take the *-im* suffix (hereafter, regular nouns) and 193 masculine-sounding nouns taking the *-ot* suffix (hereafter irregular nouns)[3]. To identify the phonological clustering of regular and irregular nouns, we classified these nouns according to their mishkalim. Any two nouns were classified as members of the same mishkal if they shared the same vowel pattern in the singular and plural form[4]. For instance, the nouns *nof-nofim, shot-shotim* fall into

[2]The definition of regularity depends on the formulation of the inflection rule. There are two possible formulations of the regular inflection rule. These versions differ with regards to the specification of gender in the description of the rule. Version one specifies gender in the rule description: it assigns *-im* suffix for masculine nouns and *-ot* for feminine nouns. Conversely, version two lacks gender in the rule description. This rule assigns the *-im* inflection to any uninflected noun, regardless of its gender (note that this rule will be overridden for feminine nouns carrying feminine suffixes, since these are productively formed by inflecting their masculine counterparts). These two rules disagree with regards to the regularity of feminine nouns that are masculine sounding and take the *-ot* plural. These nouns are considered regular according to version one, but not according to version two. Note, however, that the discrepancy between these two accounts only concerns the inflection of feminine nouns. Both accounts agree that masculine nouns taking the *-im* suffix are regular.

[3]Please note that masculine-sounding nouns taking the *-im* suffix may also include a small minority of feminine nouns. These nouns were included in the analyses for two reasons. First, because such feminine nouns occupy phonological clusters common to masculine nouns, they should constrain the inflection of their masculine neighbors, according to the distributional-asymmetry hypothesis. Second, if the default rule does not specify gender in the rule description, then such nouns are regular.

[4]Our classification allows for some predictable phonological changes in the plural form. For instance, Hebrew has 38 nouns whose singular form is CiCaCon. All these nouns take the *-ot* plural and undergo a deletion of the second vowel. However, for nouns with root initial gutturals (13 nouns), the vowel following the guttural is raised to /e/ in the plural form (cf. *pitaron-pitronot, solution*, vs. *?ikaron-?ekronot, principle*). In contrast to the largely unpredictable association between the singular and plural members, the process of vowel raising for gutturals is highly predictable (cf. *tiken, repaired* vs. *te?er, described*). It is not entirely clear how such predictable changes affect inflection, according to the pattern-associator hypothesis. Because the CiCaCon cluster is both highly consistent and distinctive (tri-syllabicity is very rare for masculine nominal patterns), gutturals could cluster with non-guttural CiCaCon nouns. To bias our classification in favor of the pattern-associator account, we included gutturals with other members of the CiCaCon mishkal, providing a larger estimate for the size of such irregular clusters.

the *CoC-CoC-suffix* pattern, hence, they are assigned to the same mishkal. Conversely, the nouns *dov-dubim*, *tof-tupim* are considered a separate mishkal, since, despite sharing the singular pattern of the *nof-nofim* mishkal, they differ in their plural form. A mishkal is considered regular if it contains at least one regular member. Likewise, an irregular mishkal is one containing at least one irregular noun. These classifications are not mutually exclusive: any given mishkal whose inflection is not entirely consistent is considered as both regular and irregular. Following these criteria, we identified in our database a total of 91 mishkalim, 84 regular and 44 irregular. We next tested for an asymmetry in the structure of regular and irregular clusters.

According to the distributional-asymmetry hypothesis, default inflection requires: (a) clustering of irregular nouns in small, distinct regions of the phonological space that are primarily irregular; (b) a diffuse distribution of regular nouns in the rest of the phonological space.

Our analyses first examined whether the phonological space includes any regions that are distinctly irregular. If large phonological clusters are dominated by irregular nouns, then large mishkalim should have a lower proportion of regular nouns. Contrary to this prediction, there is a strong positive correlation between the proportion of regular members and mishkal size ($r(89) = 0.986$, $P < 0.01$). Large phonological clusters thus tend to include a high proportion of regular members. Consequently, phonological properties are a poor predictor of irregular inflection.

Additional tests for the phonological uniqueness of irregular clusters could be sought in their consistency (the ratio of irregular nouns to the total number of nouns in the mishkal). If Hebrew had phonological clusters that are uniquely irregular, then the mean consistency of irregular mishkalim should approach one. Furthermore, if high coherence is characteristic of irregular nouns, then the mean consistency of irregular mishkalim should be higher than that of regular mishkalim. Table 3 presents the number of regular and irregular mishkalim as a function of their consistency and the percentage of regular or irregular nouns they include. Our findings provide little support for the existence of coherent 'irregular islands'. The mean consistency of irregular nouns is 0.351. Although Hebrew has one family of irregular nouns that is entirely consistent (e.g. *shitafon-shitfonot*, *flood*, including 38 nouns), most of the irregular nouns (76%) correspond to phonological clusters shared with regular nouns. Furthermore, in most of these clusters, irregular nouns

Table 3
The number of regular and irregular mishkalim and the percentage of regular or irregular nouns they include as a function of the mishkal's consistency

Consistency	Regular		Irregular	
	% nouns	# mishkalim	% nouns	# mishkalim
0–0.25	0	0	43	22
0.25–0.50	1.2	3	14.5	8
0.50–0.75	2.1	9	18.7	7
0.75–1	96.7	72	23.8	7

are overpowered by their regular neighbors. Specifically, 57% of the irregular nouns are members of mishkalim in which the irregular nouns are a minority (less than 50% of the total number of nouns in the mishkal). In contrast, regular clusters are typically consistent. The mean consistency of regular nouns is 0.7556. Practically all (99%) of the regular nouns are members of mishkalim in which regular nouns are a majority (more than 50% of the nouns in the mishkal), and 37% of the regular nouns cluster in entirely consistent families (a total of 47 mishkalim). Our analyses thus identify numerous distinctly regular clusters. In contrast, the grand majority of irregular nouns do not group in clusters consisting entirely, or even largely, of irregular nouns.

A second condition for default inflection, according to the distributional-asymmetry hypothesis, is the density of irregular clusters: irregular clusters must exhibit not only strong coherence but also high density. Conversely, regular nouns should be diffusely distributed in the phonological space. To examine the density of regular and irregular clusters, we next sorted the regular and irregular mishkalim according to their size (i.e. the number of nouns in the mishkal). For simplicity, we collapsed our data into five categories. We then examined the number of regular and irregular mishkalim of any given size, the number of nouns in each category and its share relative to the total number of regular or irregular nouns. As evident in Table 4, most irregular nouns are clustered in the smallest mishkalim (less than 10 nouns per mishkal), whereas the majority of regular nouns are members of large size clusters. Thus, irregular clusters are more sparse than regular clusters.

In summary, the clustering of masculine sounding Hebrew nouns in the phonological space differs considerably from the requirements of the distributional-asymmetry hypothesis. According to this view, default inflection requires phonologically distinct and tight clusters of irregular nouns, and a sparse distribution of regular nouns. Hebrew violates both conditions. The phonological clusters occupied by irregular nouns are largely shared with regular nouns. Furthermore, the size of regular clusters is typically larger than that of irregular clusters. Instead of coherent irregular islands in a sea of regular nouns, the most consistent islands in the phonological space correspond to regular nouns. Irregular nouns tend to form a subset of the phonological space defined by each of these islands. Given this distributional pattern, Hebrew is unlikely to exhibit a masculine regular default.

Table 4
The number of regular and irregular mishkalim (# mishkal) the number of nouns (# nouns) and their share (% nouns) as a function of mishkal size

Size	Regular			Irregular		
	# mishkal	# nouns	% nouns	# mishkal	# nouns	% nouns
1–10	37	151	8.5	39	102	52.8
10–20	24	369	20.8	4	53	27.5
20–30	7	178	10.0	0	0	0
30–40	4	138	7.8	1	38	19.7
40–140	12	942	53.0	0	0	0

The following experiments examine whether regular inflection constitutes a default for the inflection of masculine sounding nouns. Experiment 1 examines whether regular and irregular inflection differ in their sensitivity to similar stored tokens. Experiment 2 probes for the generality of regular inflection using targets that are phonologically idiosyncratic. Experiment 3 investigates whether Hebrew speakers use the regular inflection as a default for the inflection of names and borrowings.

2. Experiment 1

Experiment 1 examines two questions: (a) Does the similarity of a novel Hebrew word to an existing noun affect its inflection; and (b) Are similarity effects modulated by the regularity of these nouns. To address these questions, we employed a method previously used by Bybee and Moder (1983) and Prasada and Pinker (1993) in their investigation of similarity effects in the inflection of English past tense verbs. We constructed a set of novel words that systematically differ in their similarity to existing Hebrew nouns (hereafter, the *base nouns*). For instance, for the irregular base noun *tsinor* (*pipe*, plural: *tsinorot*), we created three non-words: *tsilor*, *tsikor*, and *bikov*. The first member of the trio, *tsilor*, differs from the base *tsinor* in one phoneme, *l*, which shares a place of articulation with the base's *n*. The second trio member, *tsikor*, is slightly less similar to the base. Like the first member, it differs from the base in the third phoneme, but the new phoneme, *k*, does not share a place of articulation with the base's third phoneme. Finally, the third trio member, *bikov* is highly dissimilar to the base, sharing none of its root consonants. The comparison of these trio members permits assessing whether the inflection assigned to the target depends on its similarity to the base. If the inflection of target words is affected by their phonological similarity to the base, then targets sharing the same place of articulation with the base (e.g. *tsilor*), should be more likely to take its inflection compared to targets that do not share the same place of articulation (e.g. *tsikor*). Each of these targets, in turn, should be more likely to agree with the base's inflection than dissimilar controls (e.g. *bikov*).

Of principal interest, however, is the modulation of similarity effects by the regularity of the base. To examine the effect of regularity, we matched each of our irregular base nouns to a regular base. For instance, the irregular base *tsinor* was matched with the regular noun *shikor* (*drunk* plural: *shikorim*). We next generated three novel words for the regular base (e.g. *shigor*, *shibor*, *midov*). The trios generated for the regular and irregular bases were matched for their similarity to their respective base (see Table 5). Participants were asked to produce the plural form for the target.

The 'word/rule' and distributional-asymmetry hypotheses converge in their view of irregular inflection as an associative process. Hence, both accounts predict that irregular inflection should be sensitive to the similarity of the target to its base. The contrast between the two views concerns regular inflection. According to the 'word/rule' account, the regular default is a symbolic process. If regular inflection is achieved solely by the default mechanism, then it should be insensitive to similarity

Table 5
An illustration of the singular members of the regular and irregular trios used in Experiment 1 and their respective base words

	Regular	Irregular
Base	shikor	tsinor
Highly similar	shigor	tsilor
Moderately similar	shibor	tsikor
Dissimilar	midov	bikov

effects: targets that are highly similar to a regular base should be just as likely to agree with its inflection as highly dissimilar targets. In contrast, the pattern-associator account views default inflection as an artifact of the distribution of regular and irregular types. Given the absence of a clear asymmetry in the distribution of regular and irregular Hebrew masculine nouns, Hebrew should not exhibit default inflection. Similarity effects should thus emerge for both regular and irregular targets.

3. Materials and methods

3.1. Participants

Twenty-one native Hebrew speakers served as participants. They were all students in the school of education at the University of Haifa. The experiment was administered as part of a course lecture. The participants received no compensation for their participation.

3.2. Materials

The materials consisted of 48 trios of words constructed by analogy to 24 pairs of existing Hebrew nouns (base nouns, see Appendix A). These base nouns serve only as models for the construction of the experimental target words, and they were not presented to the participants.

Each pair of base nouns consisted of a regular and an irregular masculine noun[5]. The regular and irregular base nouns were matched for the number of letters (mean = 4.042, SD = 0.859, for regular and irregular base nouns). Eleven of the regular and irregular pairs were also fully matched for the number of phonemes and syllables. Because the most consistent family of irregular Hebrew nouns is trisylla-

[5]Due to an error, two of the base-noun pairs included the same irregular base paired with different regular words. To assure that this error did not affect our conclusions, we conducted all analyses after excluding these two pairs. The findings were identical to the conclusions emerging with our entire data set. We thus disregarded the repetition in subsequent analyses.

bic (e.g. *yitaron*), the inclusion of such strongly irregular base nouns resulted in irregular base nouns being slightly longer in terms of the number of syllables (mean = 2.25, SD = 0.608) and phonemes (mean = 5.583, SD = 1.1) than their regular mates (for regular base nouns, the number of syllables was mean = 1.75, SD = 0.442; the number of phonemes was mean = 5.125, SD = 0.797). In the absence of a frequency count for Hebrew, it was impossible to match the regular and irregular members for their precise frequency. To assure that our base nouns are familiar, we asked a group of 12 University of Haifa students who were native Hebrew speaker to assess their familiarity on a 1–5 scale (1 = rare, 5 = familiar). The familiarity of both our regular and irregular nouns was high (mean = 4.052, mean = 4.358; for regular and irregular base nouns, respectively). Furthermore, our irregular base nouns were significantly more familiar than their regular mates ($F_s(1,11) = 14.91$, SEM = 0.038, $P < 0.01$; $F_i(1,23) = 5.72$, SEM = 0.196, $P < 0.05$). According to the 'word/rule' account, the phonological distance of the target from an irregular base is more likely to reduce its agreement with the base's inflection compared to regular bases. Conversely, the higher familiarity of our irregular bases is expected to increase agreement with the base's inflection. Thus, the greater familiarity with the irregular bases biases our materials against our hypothesis.

For each members of these 24 pairs of base nouns we constructed three targets that differ in their similarity to the base. The first and second members of the trio differed from the base in one phoneme represented by a single letter. In the first trio member, the changed phoneme shared the same place of articulation with the base, whereas in the second trio member, the changed phoneme did not share the base's place of articulation. The third member of the trio differed from the base in all three consonants corresponding to its root, but maintained its word pattern. The trios constructed to the regular and irregular bases were matched for the position of the changed letters within the word (initial, middle and final positions). The resulting 144 targets (24 pairs × 3 levels of similarity) were randomized and presented in a written list. All vowels were specified by diacritic marks.

3.2.1. Procedure

Participants were tested in a group. They were presented with the following instructions:

'In this experiment we wish to investigate how Hebrew speakers produce the plural form of new words. For this end, we invented new Hebrew words. We wish to find out what is the preferred plural form for these words.

In the following pages you will find a word in the singular form. We ask you to attempt to silently pronounce the word several times. Then, please write down next to it the plural form that sounds best to you.

Examples:
gise? *gisa? ot*
peder *pdarim*

Thank you for participating in the experiment.'

3.3. Results

Of the total responses in this experiment, 1.9% were errors consisting of failures to respond or incorrect reproductions of the stem (i.e. omission or addition of a consonant to the singular form). An ANOVA (2 regularity × 3 similarity) conducted over the error responses revealed only a marginally significant interaction ($F_s(2, 40) = 2.723$, SEM = 7.64, $P = 0.0778$; $F_i(2,46) = 2.971$, SEM = 8.004, $P = 0.0612$). None of the pairwise contrasts reached significance by Tukey HSD tests.

Correct responses consisted of the affixation of a plural suffix to the singular base. Because inflection often results in phonological changes to the stem's vowels, such changes were considered correct responses. To permit the comparison of targets constructed by analogy to regular and irregular nouns (hereafter, regular and irregular targets, respectively), we analyzed the inflection assigned to a target in terms of its agreement with the base inflection. Responses agreeing with their base inflection were regular plurals for regular targets and irregular plurals for irregular targets. The remaining correct responses reflect disagreement with the base inflection (i.e. irregular plurals for regular targets and regular plurals for irregular targets). Mean correct responses that agree with the base inflection as a function of the regularity of the target and its similarity to the base are provided in Table 6.

The effects of similarity on agreement with the base inflection were assessed by means of ANOVAs (2 regularity × 3 similarity) by participants and items. These analyses yielded significant main effects of regularity ($F_s(1,20) = 78.941$, SEM = 672.017, $P < 0.001$; $F_i(1,23) = 60.845$, SEM = 1010.975, $P < 0.001$), similarity ($F_s(2,40) = 24.355$, SEM = 56.814, $P < 0.001$; $F_i(2,46) = 19.645$, SEM = 85.756, $P < 0.001$), and their interaction ($F_s(2,40) = 41.103$, SEM = 38.562, $P < 0.001$; $F_i(2,46) = 20.811$, SEM = 85.399, $P < 0.001$). The modulation of similarity effects by the regularity of the base was further investigated using Tukey HSD post hoc comparisons.

Our findings yielded no evidence for similarity effects on the inflection of regular targets: the agreement of highly similar targets with their base inflection did not differ from moderately similar targets, which, in turn, did not differ from dissimilar targets ($P > 0.05$, by participants and items). In contrast, the inflection of irregular targets was highly sensitive to their similarity to the base. Irregular targets that were highly similar to their base were more likely to agree with its inflection compared to moderately similar targets, which, in turn, were more likely to match the base inflection than dissimilar targets ($P < 0.05$, by partici-

Table 6
Mean agreement of target inflection with its base (% correct) as a function of target regularity and its similarity to the base

Similarity	Irregular	Regular
Highly similar	60.4	90.2
Moderately similar	51.9	91.0
Dissimilar	36.9	91.1

pants and items). In fact, irregular targets that were highly dissimilar to their base took the regular default inflection in 63.1% of the correct trials. The default inflection of these targets was significantly more frequent than their irregular inflection ($F_s(1,20) = 11.342$, SEM = 632.103, $P < 0.01$; $F_i(1,23) = 5.085$, SEM = 1678.42, $P < 0.5$). Thus, as the similarity of irregular targets to their base decreases, they are less likely to agree with the base inflection. Dissimilar irregular targets are more likely to take the regular inflection over their base's irregular inflection.

3.4. Discussion

Experiment 1 demonstrates a marked contrast between the sensitivity of regular and irregular sounding targets to similarity effects. The inflection of irregular sounding targets was highly sensitive to the degree of similarity to their base: words that are highly similar to the base (e.g. *tsilor*, similar to the base *tsinor*) were more likely to take its inflection than moderately similar targets, that differ from their base in one place of articulation (e.g. *tsikor*). Highly and moderately similar targets were both more likely to take the base inflection than dissimilar targets, sharing none of its root consonants (e.g. *bikov*). Furthermore, as the phonological distance of irregular targets from their base increased, participants were more likely to inflect them using the regular default. Specifically, highly dissimilar irregular targets were more likely to take the regular *-im* inflection than their base's irregular inflection. The marked similarity effects for irregular Hebrew targets replicates the previous findings of Bybee and Moder (1983) and Prasada and Pinker (1993) with irregular English verbs. These results are consistent with the view that irregular inflection is achieved by an associative process, a prediction common to the pattern associator and 'word/rule' accounts.

In contrast to the sensitivity of irregular sounding targets to similarity effects, the inflection of regular sounding nouns was not significantly affected by their similarity to their base. The insensitivity of default inflection to similarity effects replicates the English findings of Prasada and Pinker (1993). These results are consistent with the view that regular inflection is achieved by a symbolic mechanism. However, an alternative explanation may attribute the consistent selection of regular inflection to type frequency. As evident in our database, the grand majority of masculine sounding nouns take the *-im* inflection. For these nouns, the regular *-im* inflection is far more frequent than the *-ot* inflection. The selection of the regular inflection for our targets may thus stem from its type frequency.

The appeal to type frequency is rather ad hoc, since the type-frequency hypothesis is incompatible with the evidence for default inflection in Old English and German. Thus, even if the type-frequency hypothesis was able to account for our specific findings, it clearly falls short of a principled cross-linguistic account for the acquisition of default inflection. We nevertheless tested this account by evaluating the effect of stored tokens on the inflection of our targets.

To evaluate the effect of type frequency on the inflection of our targets, we examined the neighborhood characteristics of our regular and irregular bases. We first identified the phonological neighborhood of each base noun, i.e. its mishkal. For

each base word, we calculated the number of neighbors sharing its inflection (friends) and the number of neighbors disagreeing with its inflection (enemies). An ANOVA (2 neighbors type × 2 regularity) yielded a significant main effect of neighbor type ($F(1,46) = 8.374$, SEM = 308.513, $P < 0.01$) and an interaction of neighbor type × regularity ($F(1,46) = 17.993$, SEM = 308.513, $P < 0.001$). Regular targets had more regular friends (mean = 27.83) than irregular enemies (mean = 2.25). In contrast, irregular targets had more regular enemies (mean = 15.83) than irregular friends (mean = 11).

Given that regular inflection is more frequent within the phonological clusters of our experimental targets, we next examined whether the agreement with the base inflection is sensitive to the number of its friends and enemies[6]. For this end, we computed the correlations between the probability of agreement with the base inflection and the number of regular and irregular tokens in its mishkal[7]. Our findings are provided in Table 7. The selection of irregular inflection for irregularly sounding nouns correlated positively with the number of irregular friends. This correlation emerged regardless of the similarity of the target to its base. In contrast, the selection of regular inflection for regular-sounding nouns was unaffected by the number of regular neighbors. Thus, the number of stored tokens that share the target's inflection is linked to the inflection for irregular, but not regular targets. We next examined the effect of stored tokens that disagree with the base's inflection. For regular sounding targets that are either highly similar or dissimilar from their base, the selection of irregular inflection decreased as the number of irregular neighbors increased. This finding is consistent with the view of default inflection as an 'elsewhere condition'. Regular inflection applies whenever the associative process fails. The presence of a large number of irregular neighbors activates the associative mechanism of irregular inflection, and thus overrides the default process. However, our findings also reflect a competition from regular neighbors. Specifically, there was a negative correlation between the selection of irregular inflection to irregular-sounding nouns and the number of regular neighbors.

The modulation of irregular inflection by the number of regular friends suggests that regular plurals may be stored in memory and interfere with the associative process of irregular inflection (for similar results in English, see Ullman, 1999).

[6]The effect of neighborhood structure may also be assessed by examining the ratio of friends and enemies or their difference. According to the 'word/rule' account, the default regular mechanism should be sensitive to the number of irregular enemies (via the 'elsewhere condition'). If regular inflection is achieved entirely by the default mechanism, then regular inflection should be insensitive to the number of regular friends. In contrast, irregular inflection should be sensitive to the number of irregular friends, but not necessarily to the number of regular enemies. To separately assess the effect of friends and enemies, we chose to measure neighborhood structure as the number of friends and enemies, rather than by means of a ratio or a difference score.

[7]Recall that the plural members of a single mishkal may manifest some slight variability due to predictable phonological changes (e.g. *pitaron-pitronot* vs. ?*ikaron-?ekronot*). Because it is unclear how such changes are treated by a phonological account of inflection, we performed the correlational analyses reported here and in Experiment 3 using a strict definition for mishkal. Members of the mishkal shared precisely the same word patterns in the singular and plural forms. Additional analyses conducted using various inclusion criteria reflected precisely the same qualitative results.

Table 7
The correlation between the agreement of regular and irregular targets with their base inflection and the number of their neighbors as a function of neighbor type and the similarity of the target to its base

	Neighbor type			
	Regular targets		Irregular targets	
Neighbors	Irregular	Regular	Irregular	Regular
Highly similar	–0.487*	0.169	0.634*	–0.504*
Moderately similar	–0.323	0.201	0.742*	–0.688*
Dissimilar	–0.44*	0.165	0.846*	–0.572*

Significant values are as follows: *$P < 0.05$. For comparison: the critical value for the correlation of two variables at the 0.05 levels is $r(22) = 0.404$.

This evidence is perfectly compatible with the word/rule account, since the existence of a rule for default inflection does not preclude the storage of inflected regular forms. We return to discuss this finding in Section 5. Our immediate interest, however, is in the generality of regular inflection across token characteristics. Our goal was to evaluate whether the application of regular inflection is explicable in terms of its similarity to stored regular tokens and their relative frequency. The correlational analysis provides no support for the type-frequency view. In contrast to the marked sensitivity of irregular inflection to the number of friends, there was no evidence that stored regular types increase the probability of regular inflection of targets that are either similar or distant from a stored regular word. The failure of regular friends to constrain the inflection of regular targets cannot be due to their weakness: the mean number of friends for regular targets is in fact higher than the number of friends of irregular targets. Regular inflection thus applies to targets sharing none of their bases' root consonants and it is unaffected by the size of its friendly neighborhood.

4. Experiment 2

The broad application of regular inflection for targets that are dissimilar from their regular base and its selective insensitivity to similarity and neighborhood size suggests that regular inflection may be general. Regular inflection seems to apply to any target, regardless of its phonological characteristics. This conclusion, however, is qualified by the structure of the materials used in Experiment 1. In this experiment, regular targets defined as highly dissimilar to their base did not share any of its root consonants. These targets, however, maintained the word pattern of the base. For instance, the target *taldiv* shares no root consonants with its base, *tafkid*, nor does it share the root of any other regular target. However, this target is globally similar to members of its word pattern: e.g. *tasbix*, *tafrit*, *taklit*, *targil*, *taglit*, etc. Because the *taCaCCiC* nominal pattern is both frequent and consistent, the similarity to its singular members is a good predictor of its regular inflection. The consistent selec-

tion of the *-im* suffix for this target may thus be due to the high type frequency of the *-im* inflection in its mishkal.

The type-frequency account for the inflection of dissimilar targets is challenged by several observations. First, our previous correlational analyses failed to find any evidence for the effect of regular neighbors on the agreement of dissimilar targets with their base. An additional challenge for the type-frequency account is presented by the inflection of phonologically idiosyncratic Hebrew words. If regular inflection is achieved by the activation of stored regular tokens, then words that are phonologically idiosyncratic should not be reliably assigned a regular inflection. In fact, there are several demonstrations of the failure of associative memories to provide *any* output for idiosyncratic inputs. For instance, the trained Rumelhart and McClelland (1986) model failed to provide coherent output to unusual-sounding English verbs, either existing forms (Pinker and Prince, 1988) or nonsense verbs (Prasada and Pinker, 1993). Similar results were obtained also with a hidden-layer back-propagation version of the model by Egedi and Sproat (Sproat, 1992). These failures reflect a principled limitation of pattern associators. Because idiosyncratic words include unfamiliar phonemes, they require to generalize outside the training space. Marcus (1999) demonstrated that pattern associators cannot generalize outside the training space. Thus, the inability to inflect idiosyncratic words is directly attributed to the elimination of variables, rather than to some limitations that are specific to these models or the English default rule.

Hebrew has numerous idiosyncratic words due to the frequent borrowing from foreign languages. Many of these borrowings do not fall into any of the phonological templates of Hebrew nouns, and they often include phonemes that are absent in Hebrew. For instance, the initial phoneme in *check* is not part of the Hebrew inventory. Likewise, the initial phoneme in *fax*, *phantom*, and *falafel* never appears word initially in Hebrew. Despite their phonological idiosyncrasy, such masculine-sounding borrowings are reliably inflected using the regular *-im* suffix.

To demonstrate the productivity of regular inflection for idiosyncratic words, Experiment 2 examines the inflection of non-words that are highly dissimilar from existing Hebrew words. The dissimilarity of these non-words to existing words was achieved by either introducing the foreign phoneme *ch* (pronounced as in *church*, e.g. *charlak*), by generating foreign-sounding, unusually long words (e.g. *krazastriyan*) or by violating the co-occurrence restriction on root structure (e.g. *rorod*, see Berent and Shimron, 1997; Berent et al., 1998; for discussion). These words were compared to the group of regular and irregular sounding non-words used in Experiment 1. If regular inflection is achieved by an associative process, then our idiosyncratic targets should not be consistently assigned the regular inflection. Furthermore, idiosyncratic targets should be less likely to take regular inflection compared to targets that are highly similar to existing regular words. In contrast, if regular inflection is achieved by a default symbolic process, then idiosyncratic targets should reliably take regular inflection. Furthermore, if regular inflection is sensitive solely to the constituent structure of variables, ignoring token idiosyncrasies, then the rate of regular inflection of idiosyncratic targets should not differ from that of regular targets that are highly similar to existing tokens.

4.1. Materials and methods

4.1.1. Participants

Sixteen native Hebrew speakers participated in the experiment. They were students in a University of Haifa summer course preparing them for admission. The experiment was administered as part of a course lecture. The participants received no compensation for their participation.

4.1.2. Materials

The materials consisted of 24 idiosyncratic non-words, 24 regular-sounding and 23 irregular-sounding non-words. The regular and irregular sounding words were the 'highly similar' regular and irregular targets used in Experiment 1. The idiosyncratic non-words consisted of three equal groups. One group consisted of non-words including the phoneme *ch* (e.g. *church*) that does not exist in Hebrew (e.g. *charlak*). A second group consisted of idiosyncratic non-words were unusually long and foreign sounding (e.g. *krazastriyan*). In the third group of idiosyncratic non-words, the word patterns were common, but the roots were novel sequences of three consonants that do not correspond to any existing Hebrew root. Furthermore, these roots do not correspond to *potential* Hebrew roots because they exhibit geminates root initially (e.g. *rorod*, whose root is *rrd*). Root-initial gemination violates the Obligatory Contour Principle (McCarthy, 1986). Hebrew speakers are highly sensitive to this constraint and consider root initial gemination unacceptable (Berent and Shimron, 1997; Berent et al., 1998).

4.1.3. Procedure

The procedure was as described in Experiment 1.

4.2. Results and discussion

Five of the 1136 trials (16 participants × 71 words) resulted in omission errors, two with idiosyncratic words and three with regular words. The effect of target type (idiosyncratic, regular and irregular sounding) on the proportion responses manifesting regular inflection was assessed by means of one-way ANOVAs by participants and items. The main effect of word type was significant ($F_s(2,30) = 16.94$, SEM = 191.96, $P < 0.001$; $F_i(2,68) = 19.453$, SEM = 244.3, $P < 0.001$). Our idiosyncratic words were regularly inflected in 75.5% of the trials[8]. The very high systematicity in the inflection of idiosyncratic words stands in marked contrast to the failure of pattern associators to provide any coherent output to idiosyncratic English forms (Pinker and Prince, 1988; Sproat, 1992; Prasada and Pinker, 1993). The inflection of idiosyncratic targets was not only systematic, but further reflected a

[8]Recall that our idiosyncratic words comprised of three equal groups: words containing the foreign *ch* phoneme, words exhibiting violations of the OCP and unusually long words. The proportion of regular inflection did not differ significantly for our three types of idiosyncratic words ($F_i(2,23) = 1.76$, SEM = 117.654, $P = 0.197$). The proportion of regular inflection for our *ch* targets, OCP violations, and unusually long words were 70.3%, 80.5% and 75.8%, respectively.

majority of regular responses. To rule out the possibility that this numerical majority reflects a random choice between two alternatives, the regular and irregular suffixes, we compared the observed proportion of default inflection against chance level. In view of the failure of pattern associators to generate any output to such forms, the value of the base rate is not entirely clear. A rate of 50% is certainly a conservative estimate. Our findings provide no support for this account. The rate of regular inflection for idiosyncratic was clearly higher than 50% ($t_s(15) = 4.997$, $P < 0.001$; $t_i(23) = 11.412$, $P < 0.001$). The proportion of regular inflection with idiosyncratic words was also higher than for the irregular sounding words (54.9%, $P < 0.01$, Tukey HSD comparisons, by participants and items). The most important quantitative finding of this experiment, however, comes from the comparison of responses for idiosyncratic and regular targets. The proportion of regular inflection of idiosyncratic words did not differ significantly from regular sounding words (81.8%, planned comparison, $F_s(1,30) = 1.70$, $P = 0.2026$; $F_i(1,68) = 1.99$, $P = 0.1619$). Thus, Hebrew speakers are not only perfectly capable of inflecting idiosyncratic words systematically. They specifically apply default inflection, and its rate is statistically indistinguishable from the inflection of words that are highly similar to familiar regular words.

The selection of regular inflection for idiosyncratic words demonstrates the generality of regular inflection with regards to target properties. Regular inflection applies even for targets that fall outside the phonological space of potential Hebrew words, and its rate does not differ significantly from targets that are highly similar to existing regular nouns. The relative insensitivity of regular inflection to target properties supports its view as a default: It applies across the board to any target that fails to activate the associative mechanism, regardless of its specific identity and similarity to existing words.

5. Experiment 3

The broad application of regular inflection to targets that are phonologically distant from existing words and to idiosyncratic words indicates that the similarity between a target word and a stored token is not *necessary* for its regular inflection. This finding agrees with the view of regular inflection as a symbolic process, triggered by the ‘elsewhere condition’. Experiment 3 examines a second prediction of the ‘word/rule’ account concerning the inflection of irregular words. Our findings so far indicate that irregular inflection is highly sensitive to similarity effects. Despite its critical role, however, similarity is not *sufficient* to predict the inflection of an irregular word. According to the ‘word/rule’ account, the assignment of irregular inflection does not require merely the activation of a bundle of orthographic, phonological and semantic features that correspond to an irregular word. In addition, these stored features must be labeled by a mental variable: they must be a canonical root. Words lacking a canonical root, such as names, borrowings and acronyms, cannot take irregular inflection. Importantly, the absence of a canonical root for a target will block its irregular inflection even if the root is highly similar to an

irregular token bearing the same features. By default then, words lacking a canonical root will be regularly inflected.

There are several empirical findings supporting this prediction. In a study of German inflection, Marcus et al. (1995) demonstrated that irregular-sounding nouns take an irregular inflection when presented as novel German words. However, when the same words were presented as borrowings or names, participants' preference reversed, exhibiting a marked preference for their regular inflection. The same preference was also documented among young English-speaking children. Kim et al. (1994) observed that 3–5-year-old children are more likely to assign the regular default to names that are homophonous to existing irregular nouns. Likewise, children assign the default inflection to denominal verbs that are homophonous to irregular verbs. Finally, Kim and Pinker (1995) documented the effect of rootlessness in an online production task. Their findings indicate a dissociation in the production latency of nouns and names: latency for the regular inflection of nouns increases with their similarity to existing irregular tokens. In contrast, the same targets are insensitive to similarity effects when presented as names. These findings suggest that targets lacking a canonical root block irregular inflection despite their similarity to stored tokens. The default inflection of denominals and names by young children rules out the possibility that this preference is due to literacy or schooling. In fact, default inflection of denominals emerges in the absence of any positive evidence, since denominals homophonous to irregular verbs are generally absent from the input to the child. Thus, the assignment of default inflection to denominals may not be learnable (Kim et al., 1994).

Although the assignment of default inflection to denominals cannot be inferred from linguistic evidence, linguistic evidence may be critical for the acquisition of the default. Specifically, the acquisition of regular inflection as a default in German and English may result from the asymmetry in the distribution of regular versus irregular tokens. Experiment 3 seeks to extend the investigation of the default inflection of denominals to Hebrew, a language for which default inflection is unlearnable, according to the distributional-asymmetry hypothesis. In this experiment, we examine the inflection of targets whose spelling and sound are identical to highly familiar Hebrew nouns. These targets are incorporated in sentence contexts presenting them either as native Hebrew nouns in their original Hebrew meaning, as borrowings or names. Table 8 illustrates the sentence contexts generated for the irregular noun *kir* (wall).

Because names and borrowings lack a canonical root[9], they should fail to activate

[9]We assume that irregular tokens are labeled by a grammatical category that is also marked for irregularity. Following Kim et al. (1994) and Kim and Pinker (1995), we refer to this category as the root. However, the locus of the marking in the Hebrew lexicon is not entirely clear. 'Root' in Semitic typically refers to the sequence of consonants obtained by stripping away the word pattern and affixes. If this constituent was marked for regularity, then words derived from the same root consonants should never disagree in their regularity, an incorrect prediction for Hebrew. The discrepancy between the locus of the marking in Hebrew and English is likely due to the ambiguity inherent in the definition of a root in the generative literature (Aronoff, 1994). The precise marking of Hebrew nouns for regularity requires further research.

Table 8
An illustration of the sentential contexts generated for the irregular noun *kir* (*wall*, plural *kirot*)

(a) Native Hebrew noun. In my friend's room the *kirot/kirim* are covered with paintings.
(b) Borrowing. The kir (KIR) is a French drink. To prepare two *kirim/kirot* mix two glasses of champagne and a quarter glass of Cassis liquor.
(c) Surname. My French friends Brigitte and Jean Kir arrived for a 2-week visit. The *kirot/kirim* will stay at my house during the 1st week and travel in the country during the remaining week.

the associative mechanism, taking regular inflection by default. We thus predict that the inflection assigned to these targets should be modulated by their context and regularity. Specifically, regular words should take regular inflection as either native Hebrew nouns, names or borrowings. Thus, the agreement of regular targets with their base's inflection should be independent of the context. In contrast, for irregular targets, the agreement with the base's inflection should be modulated by their context. When presented as native Hebrew nouns, irregular targets should take irregular inflection. In contrast, when the same targets are rootless, presented as names and borrowings, they should be regularly inflected, despite their identity to a stored irregular token.

5.1. Materials and methods

5.1.1. Participants

Thirty-nine native Hebrew speakers served as participants. They were all students in the school of education at the University of Haifa. The experiment was administered as part of a course lecture. The participants received no compensation for their participation.

5.1.2. Materials

The materials consisted of short contexts, including a target word presented with two alternative inflections.

5.1.3. Target words

Target words were all CVC familiar masculine Hebrew nouns (see Appendix C). There were 12 matched pairs of regular and irregular nouns. Regular targets were nouns whose plural is formed by adding the suffix *-im* to their base. Eleven of the irregular targets had *-ot* as their plural suffix (in one of these targets, *lev*, the plural also reduplicates the root's rightmost radical). An additional irregular noun, (*shook*), is inflected using the suffix *-im* (*shvakim*), but it manifests an unusual change to the base consonants. Irregular nouns whose default inflection is homophonous or identical to an existing plural noun were avoided. For instance, the word *xol* (singular masculine, *dune*), is irregularly inflected as *xolot*. However, its default inflection, *xolim*, is identical to the inflection of a regular noun, *xole* (singular masculine, *sick*). We avoided including such targets, since their regular inflection may be due to their similarity to the existing regular form (*xolim*), rather than to a productive default process.

5.1.4. Contexts

Each target word was paired with three types of short contexts: a Hebrew context, a borrowing context and a name context (see Appendix D). The Hebrew context incorporated the target word in a sentence that supports its common Hebrew meaning. The borrowing context presented the target as a foreign borrowing. It consisted of two sentences. The first established the singular meaning of the borrowing. To enhance its appearance as a foreign word, a Roman transcription of the word was provided in parenthesis. The name context presented the words as a surname. Name contexts included two sentences. The first established the singular form of the word as a surname and the second introduced its plural. The name and borrowing contexts of every irregular target were essentially identical to those paired with its regular mate (a few minor changes in nationality/language were introduced in order to make the target word appear a natural borrowing or name in the language suggested by the context).

Because the inflection of a word may depend on its gender, which is uncertain for borrowings and names, the contexts presented all borrowings and names as masculine nouns. The gender disambiguation of these nouns was achieved either by agreement (agreement with a preceding adjective or number agreement) or by pragmatics (the default gender of any group of objects including a single masculine object/person is masculine). The contexts were presented without diacritic marks. The target word and its two inflections were presented with their vowels specified by diacritic marks.

The 24 contexts were randomized and arranged in three printed lists per Latin square, such that: (a) each participant was presented with an equal number of regularity × context combinations; (b) each word or context were seen only once by any participant; and (c) each target × context combination was equally represented across participants.

5.1.5. Procedure

Participants were told that the purpose of the experiment was to examine how Hebrew speakers inflect Hebrew words, foreign words and names. Participants were not informed of the expected effect of context on inflection. They were presented with the following instructions: ‘In the following pages you will find short passages incorporating words that are underlined. Please choose the plural form that sounds best to you according to the context in which the word is presented. Please circle the best sounding option. Then, indicate the extent to which the alternative you chose sounds better than the other. If the alternative you chose sounds much better, please indicate 3; if it sounds better, indicate 2; if it is only slightly better, indicate 1.

Examples:

The radio is now broadcasting Hebrew *shirim/shirot* (3) (the correct alternative circled is *shirim*, *songs*, masculine plural).

The *sirot/sirim* (boats) are sailing in the river (3) (the correct alternative circled is *sirot*, *boats*, feminine plural).

Thanks for your participation.’

5.2. Results

Our results include two measures for the effects of context and regularity on inflection: the selection of the plural form and the rating of its superiority over the unchosen alternative. We examine the effects of context and regularity separately on each of these dependent measures.

5.2.1. The selection of plural inflection

Table 9 provides the mean responses selecting the base plural (i.e. regular inflection for regular targets; irregular inflection for irregular targets, hereafter, the *base plural*) as a function of the target regularity and context. The difference between the mean agreement with the base and 100% reflects the selection of an inflection that disagrees with the base plural (i.e. the selection of irregular inflection for regular targets; regular inflection for irregular targets). If irregular inflection requires a canonical root, then the presentation of the targets as rootless (i.e. as borrowings or names) should decrease their irregular inflection compared to their presentation as native Hebrew nouns. Furthermore, within either the borrowing or the name contexts, the choice of the base plural should be less frequent for irregular than for regular targets. Finally, the default inflection hypothesis predicts not only a *relative* reduction in the irregular inflection of rootless targets but specifically the default inflection of these targets. Thus, the selection of default inflection for irregular sounding targets should exceed chance.

To assess the effect of context and regularity, we submitted the mean selection of the base plural to ANOVAs by participants and items (2 regularity × 3 context). These analyses indicated significant main effects of context ($F_s(2,76) = 305.84$, SEM = 169.96, $P < 0.001$; $F_i(2,22) = 257.60$, SEM = 62.09, $P < 0.001$), regularity ($F_s(1,38) = 615.844$, SEM = 299.99, $P < 0.001$; $F_i(1,11) = 1477.37$, SEM = 38.48, $P < 0.001$) and their interaction ($F_s(2,76) = 158.07$, SEM = 276.75, $P < 0.001$; $F_i(2,22) = 300.819$, SEM = 44.75, $P < 0.001$). The effect of context was further investigated using Tukey HSD pairwise comparisons. Context had a marked effect on the inflection of irregular targets. Irregular targets were significantly less likely to take their base inflection when presented as borrowings or names compared to native Hebrew nouns (all $P < 0.01$, by participants and items). The decrease in the agreement of borrowings and names with their base inflection was *selective* to irregular targets. Specifically, irregular targets were less frequently inflected according to their base plural compared to regular targets in either the borrowing or name

Table 9
The percentage of responses selecting the inflection of the base Hebrew word as a function of its regularity and the context

Context	Irregular	Regular
Native Hebrew	96.80	99.36
Borrowing	16.66	90.38
Name	7.05	99.35

contexts ($P < 0.01$, by participants and items). In contrast, irregular and regular targets were equally likely to agree with their base inflection when presented as native Hebrew nouns ($P > 0.05$). Thus, the presentation of a familiar irregular target as borrowing or named, blocks its irregular inflection. Conversely, the context had a weak effect on the inflection of regular targets. The selection of the plural base in the borrowing and Hebrew contexts differed only by items ($P < 0.05$, by participants and items). The selection of the base plural did not differ in the name and Hebrew contexts (P values > 0.05, by participants and items).

The analyses performed so far indicate that the presentation of an irregular target in either a borrowing or a name context significantly reduces the selection of its base plural compared to a Hebrew context. However, the selection of the base irregular inflection for names and borrowings was not only infrequent. Participants were not simply indifferent to the inflection of these targets – they manifested a clear preference for the regular default. The default inflection was significantly higher than 50% for both irregular sounding borrowings (mean = 83.3%, $t_s(38) = 8.98$, $P < 0.001$; $t_i(11) = 8.58$, $P < 0.001$) and names (mean = 92.9%, $t_s(38) = 13.529$, $t_i(11) = 24.391$, $P < 0.001$). Likewise, the selection of regular inflection for regular targets in their borrowing ($t_s(38) = 12.902$, $P < 0.001$; $t_i(11) = 20.999$, $P < 0.001$) and name ($t_s(38) = 77.0$, $P < 0.001$; $t_i(11) = 77.003$, $P < 0.001$) contexts differed significantly from 50%. In fact, the selection of regular inflection for irregular sounding borrowings (mean = 92.9%) did not differ from the rate of regular inflection for regular native Hebrew nouns ($t(38) = 1.062$, $P = 0.2948$, n.s.; $t_i(11) = 1.593$, $P = 0.1394$, n.s). Thus, when a Hebrew word is presented as a borrowing or a name, speakers chose its default inflection regardless of the regularity of the base form. In particular, they strongly prefer the default inflection for rootless irregular nouns despite the familiarity with their irregular plural.

5.2.2. The ratings of plural inflection

A second measure of participants' discrimination among the two inflections provided for the target word may be found in the ratings assigned to the chosen inflection. To express participants' rating of the chosen inflection as a function of its agreement with the base noun, we indicate ratings assigned to the bases' inflection (e.g. the regular inflection for regular targets) by positive numbers (1 = low confidence, 3 = high confidence). Conversely, confidence for the inflection that disagrees with the base (e.g. irregular inflection for regular targets) is expressed by negative numbers (–1 = low confidence, –3 = high confidence). Mean ratings of the base inflection as a function of the regularity of the target and its similarity to the base are provided in Table 10.

The rating of the base inflection as a function of context type and regularity was assessed by means of a two-way ANOVA (2 regularity × 3 context). The analyses by participants and items revealed a significant main effect of target regularity ($F_s(1,38) = 330.016$, SEM = 1.498, $P < 0.001$; $F_i(1,11) = 1473.338$, SEM = 0.102, $P < 0.001$) and context type ($F_s(2,76) = 326.396$, SEM = 0.505, $P < 0.001$; $F_i(2,22) = 297.632$, SEM = 0.172, $P < 0.001$). The interaction of context × regularity was highly significant ($F_s(2,76) = 147.062$, SEM = 0.761, $P < 0.001$;

Table 10
The rating of the base inflection as a function of target regularity and the context

Context	Irregular	Regular
Native Hebrew	2.6474	2.8654
Borrowing	–1.5833	2.1047
Name	–2.1923	2.6218

$F_i(2,22) = 252.402$, SEM = 0.136, $P < 0.001$). The interpretation of this interaction by Tukey HSD pairwise comparisons generally matched the inflection selection findings. Context had only a modest effect on the rating of the regular inflection. Regular inflection was rated significantly higher for targets presented as nouns than for borrowings ($P < 0.05$, by participants and items), but did not significantly differ from names ($P > 0.05$, by participants and items). The rating of regular sounding borrowings and names did not differ significantly ($P > 0.05$, by participants and items). Furthermore, regular plurals for regular sounding targets were assigned high positive ratings in each of the three context levels, close to the maximum rating in the six-point scale, indicating a consistent preference for the base regular inflection. In contrast, context had a marked effect on the rating of irregular targets. Irregular plurals for irregular-sounding names were rated significantly lower than for borrowings, which, in turn, were rated lower than for irregular native Hebrew nouns (all $P < 0.05$, by participants and items). The presentation of irregular sounding nouns as names and borrowings not only reduced their agreement with their base inflection but further resulted in ratings that were significantly lower than 0 (for borrowings: $t(38) = -7.983$, $P < 0.001$; $t_i(11) = -8.07$, $P < 0.001$; for names: $t(38) = -11.4$, $P = 0.0001$; $t_i(11) = -26.299$, $P < 0.001$). These negative ratings for irregular sounding names and borrowings indicate a preference for a regular inflection. This preference cannot be due to a general rejection of irregular inflection. When presented as native Hebrew nouns, the rating for the base inflection was positive, and did not differ from the rating of the base inflection of regular targets ($P > 0.05$, by participants and items). Thus, when a familiar irregular word is presented as rootless, participants not only select the default inflection over its familiar irregular inflection, but they are also significantly more confident that this choice is preferable over the familiar irregular alternative.

5.3. Discussion

Experiment 3 demonstrates that Hebrew nouns presented as names and borrowings take regular inflection. The regular inflection of names and borrowings is observed regardless of the regularity of their base form. Specifically, names and borrowings are regularly inflected even when they are identical to an irregular noun. In fact, the frequency of regular inflection for irregular sounding names did not differ from the selection of regular inflection for familiar native Hebrew nouns. The disagreement of irregular sounding names and borrowings with the inflection of their base noun cannot be attributed to an unfamiliarity with the base inflection.

When the same targets are presented as native Hebrew nouns, irregular targets take their base's irregular inflection in 97% of the trials, and this rate of agreement does not differ significantly from regular targets. This finding confirms that these targets are highly familiar to our participants and their irregular inflection is readily available. However, when irregular targets are presented as borrowings or names, there is a dramatic reversal in their inflection: Speakers reliably prefer their regular inflection, and they are highly confident in this choice.

The reversal in the inflection of irregular sounding names and borrowings is readily explicable by the 'word/rule' account. Because these names and borrowings do not have a canonical root, they cannot activate the stored irregular root, despite their feature identity. Conversely, according to the pattern-associator view, the root, a variable, is eliminated from mental representations. On this account, the representation of words consists of a bundle of orthographic, phonological and semantic features. Variables, such as a root, or even a word, play no role in inflection. Instead, inflection is fully predictable by the target's orthographic, phonological and semantic features. The indeterminacy of the inflection of irregular sounding words by their phonological and orthographic features challenges this account. Specifically, our findings raise two questions: (1) Why is irregular inflection blocked for targets that are identical to stored tokens in their phonology and orthography? (2) Why does the blocking of irregular inflection result in the application of default inflection?

As a natural move, proponents of the pattern-associator account may search for a semantic explanation for our findings. Indeed, the meaning of our irregular sounding names and borrowings clearly differs from their noun counterparts. The mismatch between the semantic features of the target and the stored noun may block its activation[10], triggering regular inflection by default. As a result, regular, but not irregular targets, agree with their base inflection.

The following discussion examines this account. We bring several arguments against a semantic explanation for inflection. Our findings also speak against an associative account for the formation of the regular default. We demonstrate that the regular inflection of our targets is inexplicable by either type frequency or by distributional asymmetry. However, the most serious challenge to the pattern-associator account concerns its central tenet, namely, the assumption that the formation of the plural is reducibly to phonological associations between tokens.

5.3.1. A semantic account

Consider first the effects of semantic similarity on inflection. The view of irregular inflection as an associative process predicts that it should be highly sensitive to

[10]On one view, the semantic mismatch between the stored stem and borrowings or names results in the reversal of their inflection. Specifically speakers may alter the inflection of irregular inflection for names and borrowings in order to block the communication of the meaning associated with their base (Harris, 1992; Shirai, 1997). However, if a semantic mismatch promotes a disagreement with the base inflection, then it should have applied for regular targets as well (see also Kim et al., 1994, for a similar argument). Contrary to this prediction, regular sounding borrowings and names do not differ from their base nouns in their regular inflection. Thus, the disagreement of borrowings and names with their base does not simply reverse inflection across the board. Instead, the mismatch between the inflection of borrowings and names with their base is selective to irregular words.

similarity effects, including semantic similarity. Thus, a reduction in the activation of a stored irregular token for semantically distant targets is compatible with both the pattern associator and 'word/rule' accounts. However, according to the pattern-associator account, similarity effects are not selective to irregular inflection: they should also contribute to default inflection. This claim is uncertain. If the default inflection of irregular sounding names and borrowings is due to their semantic distance, then irregular words that are extensions or metaphors should take regular inflection as well. Contrary to this prediction, Hebrew has numerous irregular sounding metaphors and extensions that agree with the inflection of their irregular base. For instance, the irregular noun *tsinor* (*pipe*) takes irregular inflection in the idiom '*tsinorot mekubalim*' (literally, *accepted pipes*), indicating the proper institutional channels for resolving pending issues. Conversely, synonyms do not necessarily agree in their inflection (e.g. *tinok-tinokot*, ?*olal-?olalim*, both synonyms to *baby*). The use of irregular inflection for metaphors and regular synonyms is clearly not unique to Hebrew (e.g. see Prasada and Pinker, 1993; Marcus et al., 1995; for discussion of similar phenomena in English and German). Indeed, inflection is generally unrelated to shared meaning. Kim et al. (1991) systematically tested a semantic account for the default inflection of irregular sounding denominals in English. The status of a noun as denominal accounted for a significant share of the unconfounded variance in a regression analysis. In contrast, the semantic relatedness of denominals to their bases captured only a meager non-significant portion of the variance. Furthermore, Kim et al. (1991) observed that the preference for the regular default is not obtained for metaphors. Their findings do no support a semantic account for default inflection.

5.3.2. The type-frequency account

The above observations suggest that semantic similarity may not be sufficient to account for inflection. This conclusion, however, is not incompatible with pattern-associator accounts. Pattern-associator accounts need not be committed to a purely semantic explanation for inflection. For instance, it is possible that the orthographic and phonological form of a word is more heavily weighted in determining its inflection compared to its semantic features. Thus, semantic mismatch may decrease the activation of the base without necessarily providing a noticeable contribution for the activation of regular competitors. These accounts are perfectly tenable, as long as they can propose an alternative explanation for the activation of the regular default. Two such proposals are currently available: type frequency and distributional asymmetry. The distributional-asymmetry account is strongly challenged by the overlap in the distribution of regular and irregular Hebrew nouns in the phonological space. However, regular inflection is clearly more frequent than irregular inflection for masculine sounding Hebrew nouns. Thus, type frequency is potentially a viable explanation for the activation of regular Hebrew forms. We now turn to test it for our data.

We first examined whether regular inflection is indeed a more frequent type within the phonological clusters of our experimental targets. For this end, we calculated the number of regular and irregular neighbors within the mishkalim of our

Table 11
The correlation between the proportion of regular inflection and the number of regular and irregular neighbors as a function of target regularity and context

Context	Neighbor type			
	Regular targets		Irregular targets	
	Regular	Irregular	Regular	Irregular
Borrowing	0.051	0.17	0.075	0.138
Name	0.058	0.15	–0.093	0.299

regular and irregular targets. An ANOVA (2 target type (regular vs. irregular) × 2 neighbor type (friend vs. enemies)) yielded a significant interaction (F_i (1,22) = 9.848, SEM = 556.733, $P < 0.01$). Irregular targets had more regular enemies (mean = 22.5) than irregular friends (mean = 9.75). In contrast, for regular targets, the number of regular friends (mean = 34.417) exceeded their irregular enemies (mean = 4.417). Thus, regular inflection was clearly dominant within the phonological clusters of our irregular targets. We next examined whether the assignment of regular inflection to names and borrowings is sensitive to type frequency. If the regular inflection of names and borrowings depends on the sharing of orthographic and phonological features with existing regular nouns, then our findings should exhibit significant correlation between the probability of regular inflection and the number of regular neighbors. Our findings are provided in Table 11. There was no evidence for a correlation between regular inflection and the number of regular neighbors for either borrowings or names ($P > 0.05$; for comparison: the relevant critical value for the correlation of two variables is $r(10) = 0.576$). Likewise, the correlation between regular inflection and the number of irregular neighbors did not approach significance for either of the target or context types ($P > 0.05$). Thus, there is no evidence that the selection of regular inflection is sensitive to its type frequency.

5.3.3. Is inflection achieved by an associative phonological process?

Our discussion so far failed to find any support for the attribution of default inflection to an associative process. The selection of the regular plural seems insensitive to semantic similarity. It is also inexplicable by the type frequency of regular inflection. Thus, the associative account for the formation of default plural is unclear. However, the challenge for the associative account goes beyond its inability to specify *how* default inflection emerges from stored associations. It is the assumption that default inflection *is* reducible to phonological associations between stored tokens that is incompatible with our findings.

Pattern-associator accounts of morphology embody a tacit theory of grammar, a theory that could be made explicit by comparison to traditional linguistic accounts (Pinker and Prince, 1988). Many linguistic theories distinguish between morphology

[11]The view of morphology as autonomous does not preclude the interaction of morphological and phonological semantic or syntactic processes. It merely states that the principles governing word formation are irreducible to non-morphological principles (Aronoff, 1994, p. 63).

and phonology as separate, partly autonomous[11] components of the grammar. These components jointly contribute to the surface form of the plural. For instance, consider the production of the plural *dogs*. The phonological form of *dogs* is a product of two sources: morphology is responsible for the selection of the suffix, whereas phonology independently predicts its voicing. In contrast, pattern-associator accounts eliminate morphology. They entail no component that is responsible for word formation independent of phonology. Inflection is thus viewed as a phonological change to the singular form. Furthermore, this phonological account of inflection eliminates mental variables, categories such as a stem and noun. The phonological process of inflection is constrained solely by the distribution of stored tokens: it applies to all tokens regardless of their grammatical categories. Thus, the inflection of nouns lacking a canonical root (e.g. borrowings and names) is not fundamentally distinct from the inflection of native Hebrew nouns. They are each explicable by the same set of stored phonological associations. Our findings challenge these predictions.

Recall that Hebrew nouns are formed by inserting the root in a word pattern, the mishkal. The inflection of Hebrew nouns frequently results in phonological changes to the stem. These changes apply to all members of the mishkal, regardless of their morphological suffix (e.g. *kelev-klavim*, *dog*; *kever-kvarot*, *grave*). Thus, the mishkal is a very strong predictor of the phonological form of plural nouns. If the regular inflection of borrowings and names was a phonological process, achieved by the activation of stored nouns, then the plural form of borrowings and names should have *fully* agreed with the plural form of similar native nouns. In particular, borrowing and name plurals should have agreed with regular nominal plurals not only in their inflectional suffix, *-im*, but also in their phonological form. Contrary to this prediction, the phonological forms of Hebrew borrowings and names routinely mismatch with the phonological forms of native nouns, despite their agreement in inflectional suffix. The plurals of names and borrowings exhibit no stress shift, nor do they undergo vowel changes to their stems. Borrowings and names fail to undergo phonological changes even when they are identical to an existing native

Table 12
The dissociation between the morphological and phonological form of nominal plurals and phonologically similar borrowings and surnames (primary stress is indicated by an accent to the vowel)

(a) Native nouns versus borrowings				
CiC	kis-kisím	*pocket*	bis-bísim	*bite*
CoC	shot-shotím	*whip*	shóck-shóckim	*shock*
(b) Native nouns versus surnames				
CoCeC	cohén-cohaním	*priest*	Cóhen-cóhenim	
CeCec	régev-regavím	*clod*	Régev-régevim	
CaCiC	ravív-revivím	*rain shower*	Ravív-ravívim	
CaCaC	barák-brakím	*lightening*	Barák-barákim	

noun. Table 12 illustrates this phenomenon. The first part of the table lists several native nouns and borrowings that share the mishkal and plural suffix, but disagree in their plural phonological form. The second part of the table lists surnames that are homophonous to native Hebrew nouns. Despite the identity of the singular forms and the agreement in plural suffix, the phonological forms of these plurals are quite different: phonological changes to the stem apply to nouns, but are blocked for their name counterparts. The dissociation between agreement in suffix and agreement in phonological form is incompatible with the view of inflection as a phonological process. Furthermore, the sensitivity of these processes to the presence of a canonical root challenges the view of inflection as an associative process.

In summary, our findings present several challenges to the pattern-associator account. The default inflection of irregular sounding borrowings and names is not due to a semantic mismatch, nor is it predicted by the type frequency of regular friends. Most importantly, the mismatch between the phonological form of names and borrowings and that of their stored native regular nouns is incompatible with the attribution of inflection to an associative phonological process.

6. General discussion

This research examines the inflection of masculine sounding Hebrew nouns. Our investigation addresses two questions: (1) Does the regular *-im* inflection constitute a default for the inflection of masculine sounding nouns? (2) Is default inflection achieved by a symbolic process? In discussing these questions, we first review our evidence for the presence of default inflection in Hebrew. We next examine its computation. Finally, we briefly address the implications of our findings to online accounts of inflection.

6.1. Does Hebrew have a default for the inflection of masculine-sounding nouns?

The view of regular inflection as a default predicts that its application is general, regardless of the similarity of the target to existing regular tokens. It is triggered by an ‘elsewhere condition’ upon the failure to activate a similar irregular token in associative memory.

Experiment 1 demonstrated that regular inflection applies to non-word targets that are phonologically distant from their base nouns. Experiment 2 established the generality of regular inflection for highly idiosyncratic non-words, targets whose phonology grossly deviates from the phonological characteristics of potential Hebrew words. Speakers not only reliably choose regular over irregular inflection for these targets; their selection is relatively *insensitive* to phonological similarity. The frequency of regular inflection for dissimilar and idiosyncratic non-words does not differ significantly from the frequency of its selection for targets that are highly similar to regular nouns, nor is it affected by the number of stored regular nouns. These findings are consistent with the claim that regular inflection applies generally, regardless of the similarity of the target to stored tokens.

Our findings also lend support for the overriding of default inflection by the activation of irregular words. In contrast to the generality of default inflection, irregular inflection is highly sensitive to similarity effects. Experiment 1 demonstrates that the selection of irregular inflection increases with the phonological similarity to a stored irregular noun. Likewise, irregular inflection positively correlates with the number of irregular neighbors. Experiment 3, however, presents an interesting qualification to the scope of similarity effects. This experiment examined the inflection of existing regular and irregular nouns presented as native Hebrew nouns, names and borrowings. Its results demonstrate that targets identical to existing irregular nouns are nevertheless assigned the default inflection when presented as names and borrowings. These findings suggest that the activation of an irregular stored noun does not depend merely on its similarity to the target. Instead, irregular inflection requires also a formal property, namely the presence of a canonical root (Kim et al., 1991, 1994; Kim and Pinker, 1995; Marcus et al., 1995).

Indeed, there is a growing body of evidence demonstrating the representation of Hebrew roots by a variable. For instance, the identification of Hebrew words is facilitated by priming them with their root (Bentin and Feldman, 1990; Feldman and Bentin, 1994; Frost et al., 1997), and its productivity determines the ease of decomposing the root from the word pattern (Feldman et al., 1995). Hebrew speakers further constrain root structure and their knowledge is inexplicable by the co-occurrence of subword units (Berent and Shimron, 1997; Berent et al., 1998). Our findings suggest that the root[12] is also critical for irregular infection. Irregular inflection requires that the target has a root that is similar to a stored irregular root. In the absence of a canonical root, irregular inflection is blocked, triggering default inflection. Thus, the similarity to stored irregular tokens is necessary, but not sufficient to override default inflection.

6.2. Is the regular default computed by a symbolic process?

Given the evidence for the existence of default inflection in Hebrew, we now turn to examine its source. According to the 'word/rule' account, the regular default is computed by a symbolic mechanism (Pinker, 1991, 1994, 1997, 1999). Conversely, pattern-associator accounts view default inflection as the product of an associative process (e.g. Rumelhart and McClelland, 1986; MacWhinney and Leinbach, 1991; Plunkett and Marchman, 1991, 1993; Daugherty and Seidenberg, 1992; Hare and Elman, 1995; Hare et al., 1995).

We investigated two associative accounts for the emergence of default inflection in an associative system: the distributional-asymmetry hypothesis and the type-frequency account. The existence of a regular default in Hebrew is incompatible with either view. The distribution of regular and irregular tokens in Hebrew violates

[12]Given the ambiguity concerning the notion of the root (Aronoff, 1994), it is uncertain whether the linguistic variable carrying the marking of regularity (to which we refer as the root) is identical in all respects to the level implied by the empirical findings cited above. We expect some differences between these two notions, but this question awaits further research.

the requirements of the distributional-asymmetry hypothesis (Hare et al., 1995; Plunkett and Nakisa, 1997). Instead of strong clusters of irregular tokens in the midst of diffusely distributed regular tokens, Hebrew irregular clusters constitute a subset of the regular regions and their density is quite similar. Our findings are also inexplicable by the type-frequency account (e.g. Rumelhart and McClelland, 1986; Plunkett and Marchman, 1991, 1993; Daugherty and Seidenberg, 1992; Bybee, 1995). Regular inflection appears insensitive to the frequency of regular types. Specifically, although irregular inflection was affected by the number of stored irregular nouns, regular inflection did not correlate with the number of regular friends in any of our experiments and emerged even for phonologically idiosyncratic targets. The inflection of Hebrew nouns is thus unaffected by either the similarity to specific regular nouns or by the global similarity to potential Hebrew nouns.

The challenge presented by our findings, however, goes beyond the inadequacy of *specific* associative accounts of default inflection. It is their fundamental tenet, namely, the view of inflection as a set of token-specific associations, that is questioned by our results. One challenge concerns the reduction of default inflection to phonological associations. If regular inflection was merely a phonological modification of the target according to similar stored tokens, then all plural forms generated from a single base should have fully agreed in both their phonological form as well as the plural suffix. Contrary to this prediction, the plurals of Hebrew names and borrowings disagree with the plurals of regular nouns despite their agreement on inflectional suffix and the identity of their singular forms.

A deeper challenge to the associative account is presented by the convergence of the evidence for default inflection across languages. The characteristics of default inflection in Hebrew agree with the findings reported in English and German (e.g. Kim et al., 1991, 1994; Prasada and Pinker, 1993; Kim and Pinker, 1995; Marcus et al., 1995). In each of these languages, the default is productively used for new words, regardless of their similarity to stored tokens. It is also used for the inflection of rootless nouns, such as borrowings and names. To account for the role of the default as the inflectional class preferred for new nouns, names and borrowings, an associative account must resort to specific associations between the phonological form of the default and the semantic properties of these categories. Because such associations must be acquired from experience by rote learning, independently in each of these languages, their cross-linguistic convergence is a puzzling coincidence. For instance, if the use of the default for names and borrowings in English is merely an association between the specific phonological properties of its nominal default suffix (*s*) and the semantic features of nouns and borrowings, then why does Hebrew, a language whose phonology and default suffix are quite distinct from English, exhibit the same association?

The emergence of a default inflection in Hebrew, its independence from phonological regularity and the cross-linguistic convergence in the circumstances of its application are currently unaccounted for by the associative view of inflection. In contrast, these observations are readily explicable by the view of regular inflection as a symbolic process, a process sensitive to the combinatorial structure of variables. The blindness of symbolic processes to the tokens enumerated by variables nicely

explains the insensitivity of regular inflection to similarity and type-frequency effects, whereas their sensitivity to linguistic variables accounts for the regular inflection of rootless nouns that are irregular sounding. The view of default inflection as a morphological process, autonomous from phonology, also explains the dissociation between the morphological and phonological properties of rootless nouns and nouns with canonical roots. Finally, the cross-linguistic convergence in the circumstances triggering default inflection is predicted by the hypothesis that the distinction between productive grammatical rules and word associations is a design feature of the human mind (Pinker, 1991, 1994, 1997, 1999).

6.3. Implications for language processing

Our findings strongly support the existence of a default symbolic mechanism for the inflection of Hebrew nouns. However, these results cannot determine its contribution to the online computation of regular forms in language processing. In particular, the symbolic computation of default inflection does not preclude the storage of familiar regular forms in memory. In fact, the storage of some regularly inflected forms may be required by the 'word/rule' account. For instance, consider doublets, like *dive-dived* versus *dive-dove*. The view of default inflection as an 'elsewhere condition' assigns a precedence for irregular inflection. The activation of the irregular verb *dove* should thus block its default inflection. Likewise, regular verbs that are phonologically similar to stored irregular verbs (e.g. rhymes) are likely to trigger the irregular mechanism (e.g. *blink* vs. *drink and sink*). Because irregular-sounding words override the default mechanism, their regular inflection must be stored, a prediction supported by the findings of Ullman (1999). The storage of regular forms may even go beyond cases in which it is necessary to achieve regular inflection. The mere familiarity with inflected forms may be sufficient to result in their storage. Indeed, several studies observed a facilitation in the processing of regularly inflected words whose surface token frequency is high (Taft, 1979; Burani et al., 1984; Katz et al., 1991; Sereno and Jongman, 1997). These results suggest that regularly inflected forms may be stored in the mental lexicon.

The findings of our Experiment 1 converge with this conclusion. We observed a negative correlation between the selection of irregular inflection for irregular-sounding words and the number of regular friends. This finding suggests that regular plurals are stored in memory and compete with the activation of irregular plurals. Although our present results found no evidence for the effect of stored regular forms on regular inflection[13], such possibility is not incompatible with the 'rule-word' account. The 'word/rule' account predicts the existence of a default mechanism, it does not require that this mechanism is the sole source of constraints on regular inflection. Thus, the effect of regular neighbors is, in principle, compatible with both

[13]A replication of Experiment 1 using a rating task found some weak evidence of the modulation of regular inflection by the similarity of the target to stored regular tokens. Because the effect of similarity was not reliable, the source of this trend is still unclear. Further research is required to establish whether regular inflection in Hebrew is partly sensitive to stored regular tokens, and whether these effects depend on the experimental task.

the 'word/rule' account as well as with an associative account. It is the absence of neighborhood effects, and more generally the power of regular inflection to apply without requiring neighbors at all, that is uniquely predicted by the 'rule-word' account. Thus, unlike irregular inflection, neither the storage of inflected regular forms nor their effect on processing is necessary. The division of labor between storage and computation in processing familiar regular words awaits further research. The goal of the present investigation was to establish the existence of default inflection in Hebrew and examine its computational properties. We demonstrated that Hebrew nominal inflection exhibits a regular default and its computation is achieved by a symbolic process. The convergence of the circumstances triggering regular inflection in Hebrew, English and German suggests that the capacity for default inflection may be general.

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Appendix A. The targets employed in Experiment 1 and their respective regular and irregular bases[14]

(a) Regular targets

Base	Similar	Medium	Dissimilar	Gloss
xidon	xiton	xigon	?igon	quiz
shikor	shigor	shibor	midov	drunk
kvish	kfish	knish	sniv	road
xaruz	xaluz	xamuz	?amuv	bead
gibor	gipor	gishor	dishov	hero
gar?in	garxin	garmin	bardin	kernel
taxshit	taxsit	taxgit	tamgiv	jewelry
tasbix	taspix	tasgix	tangir	complex
tafkid	tafgid	tafnid	taldiv	role
tafrit	tavrit	tamrit	tamkil	menu
takdim	tagdim	tandim	tafsiv	precedent
taklit	taknit	takshit	tangis	record
targil	tarkil	tarsil	tavsix	exercise
ze?ev	se?ev	le?ev	ledek	wolf
kfar	ktar	kmar	gmaf	village
klal	kral	kdal	shdan	rule
pgam	pkam	plam	dlav	imperfection
saxkan	saxgan	saxman	parman	actor
pras	plas	ptas	shtav	prize
meitar	meisar	meivar	geilan	string
tslav	tsrav	tsgav	blad	cross

[14]In the above transcription, ? stands for a glottal stop (e.g. the first consonant in ?*aba*, father) and *x* stands for a velar fricative (e.g. *xutzpa*). The digraphs *ts* and *sh* each stand for a single consonant marked by a single letter in the Hebrew alphabet.

(a) Regular targets

batsal	batsan	baman	gaman	onion
mabat	mapat	madat	shadav	look
kadur	katur	karur	balud	ball

(b) Irregular targets

Base	Similar	Medium	Dissimilar	Gloss
vilon	vinon	vikon	kixon	curtain
tsinor	tsilor	tsikor	bikov	pipe
rexov	re?ov	renov	kenod	street
xalom	xanom	xadom	?adov	dream
kinor	ginor	binor	bilod	violin
yitaron	yidaron	yigaron	bigavon	advantage
kisharon	kitaron	kimaron	bimadon	talent
pikadon	pigadon	pisadon	misagon	deposit
shitafon	shitavon	shitagon	bigalon	flood
dika?on	diga?on	diaba?on	libaron	depression
gilayon	ginayon	gipayon	mipalon	page
nikayon	nigayon	nibayon	mibanon	cleaning
?ikaron	?igaron	?ilaron	shibalon	principle
neyar	leyar	peyar	pelash	paper
krav	knav	k?av	b?an	battle
shtar	shzar	shnar	gnal	violin
mazal	masal	mabal	gabad	luck
shulxan	shul?an	shulban	burban	table
sulam	sunam	subam	kubax	ladder
?otsar	?ozar	?okar	xokal	treasure
zanav	sanav	manav	lagar	tail
gader	gaden	gadev	banev	fence
makel	magel	masel	basen	stick
tsinor	tsilor	tsikor	bikov	pipe

Appendix B. The idiosyncratic targets employed in Experiment 2

charlak
chanchan
chelek
kechet
forchem
chetnik
chiv
chang
rorod
xaxd
kokol
bobof

Appendix B. *continued*

?o?er
gogof
xixit
kokol
barnakofol
stodnimitz
konomalek
parnakover
gromitsakel
drovanogov
krazastriyan
blakovnikov

Appendix C. The regular and irregular targets used in Experiment 3, their gloss and plural forms

Irregular			Regular		
Singular	Gloss	Plural	Singular	Gloss	Plural
?or	light	?orot	goor	cub	goorim
lev	heart	levavot	lool	chicken-coop	loolim
bor	pit	borot	bool	stamp	boolim
dor	generation	dorot	nof	view	nofim
zoog	pair	zoogot	zif	bristle	zifim
mot	bar	motot	moom	blemish	moomim
sod	secret	sodot	soog	kind	soogim
kol	voice	kolot	kis	pocket	kissim
kir	wall	kirot	tsook	cliff	tsookim
gag	roof	gagot	gan	garden	ganim
shook	market	shvakim	toot	strawberry	tootim
xov	debt	xovot	xoog	workshop	xoogim

Appendix D. The sentential contexts for the regular and irregular targets used in Experiment 3

(1) or

I am afraid to stay in my room in the dark. Please turn on the bright *orot/orim*.

The orr (Orr) is a pleasantly sounding Balinese percussive instrument similar to the xylophone. During my travels in Bali, I used to listen for hours to the orchestra of *orim/orot* playing in the cafe near my hotel.

Yosef and Michal Or live upstairs. The *Orot/Orim* tend to make lots of noise at night and wake me up from my sleep.

Appendix D. *continued*

(2) lev

The defendants on the trial waited for the verdict, their *levavot/levim* pounding.

The lev (Leiv) is a sardine that the Swedish cook with great amounts of salt. Because of its saltiness, it is customary to serve only two *levavot/levim* per serving.

The children of the Lev family are known for their musical talent. Dani Lev plays the violin, Michal Lev plays the piano and their young brother, Alon, plays the cello. The *Levavot/Levim* play in a musical trio that was enthusiastically hailed by the press.

(3) bor

In Jerusalem's Old City, deep *borim/borot* for collecting rain water were found.

The bor (Boar) is a wild pig that is common in North America. The number of *borot/borim* has recently declined, and they are near extinction.

The Bor family counts eight people. The poor *Borim/Borot* have never gone on a family vacation because their car has only five passenger seats.

(4) dor

The Cohen family is one of the oldest in the Moshav. The family members have lived in the area for six *dorot/dorim.*

The dor (DOR) is a computer chip produced in the US. The installation of three tiny *dorim/dorot* will increase your computer's speed tenfold.

Yesterday I invited my friends Ilan and Ruth Dor for dinner. The *Dorot/Dorim* always arrive late, so I invited them two hours before the other guests.

(5) zug

On Friday evening, the restaurants are always full, so I called early and reserved a table for three *zugim/zugot.*

The Indians of North Brazil refer to the spirit of the dead as a zug (Zoog). To appease the angry *zugot/zugim*, the Indians serve them offerings and pray for their sake.

My last name, *Zug*, is relatively rare. To date, I have found only five *Zugim/Zugot*, and none of them is related to me by family.

(6) mot

To maintain the stability of the tent, install the supporting *motot*/*motim* deep in the soil.

The mot (Moat) is a huge butterfly that is common in the central Amazon. During the rainy season, the jungle is filled with thousands of *motim/motot* in a variety of beautiful colors.

The couple Edna and Yosef Mot are well known scientists. To date, the *Motot/Motim* have published hundreds of papers in common.

(7) sod

Because of his position at the Defense Ministry, Dan Marom is exposed to classified state *sodim/sodot*.

The English gardeners excel at growing the common sod (Sod). At spring time, the *sodot/sodim* bloom in a beautiful blossoming.

Michal and Yosef Sod are known for their strange taste in clothes. Often times the

Appendix D. *continued*

Sodim/Sodot tend to wear one black shoe and one white shoe.

(8) Kol

Schizophrenia patients tend to hear internal *kolot/kolim* that order them to perform dangerous acts.

Kibutz Snunit has recently started growing the kol (col) – a Mexican cabbage that is very nutritious. Eating three *kolim/kolot* provides you with all the vitamins necessary for your health.

The German chancellor Helmut Kohl and his wife arrived for a state visit in Israel. The *Kolot/Kolim* received a warm welcome at the residence of the Israeli president. (Note: all targets' spellings are identical in the Hebrew original.)

(9) kir

In my friend's room, the kirot/kirim are covered with paintings.

The kir (KIR) is a French drink. To prepare two *kirim/kirot*, mix two glasses of champagne and a quarter glass of Cassis liquor.

My French friends Brigitte and Jean Kir arrived for a 2-week visit. The *Kirot/Kirim* will stay at my house during the 1st week, and travel in the country during the remaining week.

(10) gag

When you fly over Tel Aviv, the *gagim/gagot* look like a beautiful rug.

The gag (Gahg) is a German device used by dentists to prevent patients from closing their mouth during therapy. My dentist always teases me when the *gagot/gagim* are inserted in my mouth, but unfortunately, I cannot reply.

The American Jazz singer Paul Gag and his wife, the pianist Susan, arrived for a concert tour. The *Gagim/Gagot* will perform in an open concert in Gan Hapa'amon in Jerusalem.

(11) Shook

Before the new year, the overcrowding at the wholesaler has increased, and the prices of fruits and vegetables have skyrocketed.

The shook (shook) is a Mongolian drink made of Yak blood. After drinking two *shookim/shvakim*, I immediately overcame the horrible cold.

The famous Hungarian Pianist Istvan Shook and his wife, the violinist Ilona arrived for a concert tour. The *shvakim/shukim* will perform in the Jerusalem Theater and Tel Aviv Museum.

(12) Xov

Because of the financial crisis, I sank in deep *xovim/xovot*.

The Mayan collected rain water in a special container known as the xov (Xov). Archeological excavations revealed 21 *xovot/xovim* in different sizes.

During my visit in Kazachstan I became very friendly with the Xov family and stayed at their home for a whole week. The *Xovim/Xovot* are wonderful hosts, and I will never forget their generosity.

(13) gur

My German Shepherd gave birth to four *gurim/gurot*.

The gur (Goor) is a pleasantly sounding Balinese percussive instrument similar to

Appendix D. *continued*

the xylophone. During my travels in Bali, I used to listen for hours to the orchestra of *gurot/gurim* playing in the cafe near my hotel.

Yosef and Michal Gur live upstairs. The *gurim/gurot* tend to make lots of noise at night and wake me up from my sleep.

(14) lool

Last night, the jackals entered the lit loolot/loolim and destroyed tens of chickens.

The lool (Lool) is a sardine that the Swedish cook with great amounts of salt. Because of its saltiness, it is customary to serve only two *loolot/loolim* per serving.

The children of the Lool family are known for their musical talent. Dani Lool plays the violin, Michal Lool plays the piano and their young brother, Alon, plays the cello. The *loolot/loolim* play in a musical trio that was enthusiastically hailed by the press.

(15) bool

To send the letter by air mail, put on the envelope three *boolim/boolot*.

The bool (Bule) is a wild pig that is common in North America. The number of *boolot/boolim* has recently declined, and they are near extinction.

The Bool family counts eight people. The poor *Boolim/Boolot* never have gone on a family vacation since their car has only five passenger seats.

(16) nof

The *nofot/nofim* from the Galil heights are breathtaking.

The nof (NOF) is a computer chip produced in the US. The installation of three tiny *nofim/nofot* will increase your computer speed tenfold.

Yesterday I invited my friends Ilan and Ruth Nof for dinner. The *nofot/nofim* always arrive late, so I invited them two hours before the other guests.

(17) zif

My daughter, Noga, refuses to let Dad kiss her in the morning, because the *zifim/zifot* in his beard sting.

The Indian in North Brazil refer to the spirit of the dead as a zif (zif). To appease the angry *zifot/zifim*, the Indians serve them offerings and pray for their sake.

My last name, zif, is relatively rare. To date, I have found only five *zifim/zifot*, and none of them is related to me by family.

(18) mum

The amniocentesis test is preformed in order to discover hereditary *mumot/mumim* in the fetus.

The mum (Moom) is a huge butterfly that is common at the central Amazon. During the rainy season, the jungle is filled with thousands of *mumim/mumot* in a variety of beautiful colors.

The couple Edna and Yosef Moom are well known scientists. To date, the *moomot/moomim* have published hundreds of papers in common.

(19) sug

The waitress served three *sugim/sugot* of meat for dinner.

The English gardeners excel at growing the common sug (Soog). At spring time, the *sugot/sugim* bloom in a beautiful blossoming.

Appendix D. *continued*

Michal and Yosef Soog are known for their strange taste in clothes. Often times the *sugim/soogot* tend to wear one black shoe and one white shoe.

(20) kis

My pants have four *kisot/kisim*: two in the front and two at the back.

Kibutz Snunit has recently started growing the kis (kis) – a Mexican cabbage that is very nutritious. Eating three *kisim/kisot* provides you with all the vitamins necessary for your health.

The Hungarian prime minister Janos Kiss and his wife arrived for a state visit in Israel. The *kisim/kisot* received a warm welcome at the residence of the Israeli president.

(21) tsook

My friend Dani enjoys climbing steep *tsookim/tsookot* in the Jehuda desert.

The tsook (Zook) is a German drink. To prepare two *tsookot/tsookim*, mix two glasses of champagne and a quarter glass of Cassis liquor.

My Hungarian friends Istvan and Ilona Tsook arrived for a 2-week visit. The *Tsookim/Tsookot* will stay at my house during the first week, and travel in the country during the remaining week.

(22) gan

The city of Tel Aviv will soon build tens of new public *ganot/ganim*.

The gan (Gahn) is a German device used by dentists to prevent patients from closing their mouth during therapy. My dentist always teases when the ganim/ganot are inserted in my mouth, but unfortunately, I cannot reply.

The American Jazz singer Paul Gan and his wife, the pianist Susan, arrived for a concert tour. The *Ganot/Ganim* will perform in an open concert in Gan Ha'pamon in Jerusalem.

(23) toot

For dessert, I served red *tootim/tootot* with cream.

The toot (Toot) is a Mongolian drink of Yak blood. After drinking two *tootot/tootim*, I immediately overcame the horrible cold.

The famous British pianist John Toot and his wife the violinist Mary arrived for a concert tour. The *tootim/tootot* will perform in the Jerusalem Theater and Tel Aviv Museum.

(24) xug

My 7-year-old son is enrolled in three scientific *xugot/xugim*: biology, math and computers.

The Mayans collected rain water in a special container known as the xug (Xug). Archeological excavations revealed 21 *xugim/xugot* in different sizes.

During my visit in Kazachstan I became very friendly with the Xug family and stayed at their home for a whole week. The *xugot/xugim* are wonderful hosts, and I will never forget their generosity.

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