PSYCHOLOGICAL REALITY OF
SEQUENTIAL VOICING ("RENDAKU")
IN MODERN STANDARD JAPANESE:
Its Acquisition and Development

Ikuto Koga

Submitted for the degree of PhD in Phonetics

University College London

2003
To Sophie,

To my parents
Abstract

The thesis is a psycholinguistic study of **Sequential Voicing** (known as **Rendaku**) in modern Japanese. Rendaku is a morphophonemic alternation whereby an initial voiceless obstruent of the second constituent of a compound undergoes voicing. It is infamous for its irregularity, which is attributed to more than a dozen conditioning factors.

The study questions its status as a ‘productive phonological rule’ and investigates the way in which it is acquired and developed by 131 adult and non-adult native speakers. The psychological reality of Rendaku is tested orally by means of an elicited production test and by an acceptability test, both involving nonsense words as compound constituents. Two theories join forces to interpret the results. **Optimality Theory** provides the most up-to-date analysis of Rendaku, notably of the OCP[+voice, -son] effect (the disfavouring of adjacent voiced obstruents) that blocks the phenomenon. It also enables the construction of a model of multi-staged developmental grammars, each identified by a unique constraint ranking and its outputs. The **dual-mechanism model** of morphological learning, supplemented by findings on morphological representations and the acquisition of compounds, explains how regular and irregular aspects of Rendaku can be handled differently in the cognitive system.

The results show: 1) late acquisition, presumably triggered by the growth in vocabulary and general cognition, 2) low productivity, indicating the weakness of the process, 3) OCP[+voice, -son] as a near-categorical constraint, 4) the distance effect of the OCP, 5) the absence of productive Rendaku for the majority of subjects, 6) psychologically real effects of some phonological conditions, 7) notable individual variations, for instance the preference of voicing certain obstruents. It is concluded that for most subjects Rendaku is not a productive rule of grammar as often described, but is largely a part of generalizations in the lexicon. Different speakers seem to construct different I-linguistic generalizations about Rendaku, which suggests the idea of “parametric poverty” – that is that certain parameters may be set randomly or left unset.
Acknowledgements

I would like to express my thanks to John Maidment, my supervisor, for countless hours of tutorials and guidance since I started my MA at UCL. There are two people I am deeply indebted to: Neil Smith, for his prompt and precise comments on early drafts, valuable suggestions, and fascinating lectures on almost every aspect of language, philosophy and Chomsky. Also, to Moira Yip, for her generous and inspiring discussions, detailed and acute comments on continual draft submittals, useful references, and expertise in Optimality Theory and phonology in general. Without these people’s input, I would have been lost. I want to also express my gratitude to a number of other people. My second supervisor, Michael Ashby, for his clever and fun ideas on the experiments, Molly Bennett for her encouragement and providing us with a research room, and Mitsuhiro Nakamura for introducing me to the frightening and fascinating world of Rendaku.

Very special thanks go to Axel Petzold for his dedicated support on statistics. I would also like to express my heartfelt gratitude to Mizue Itō, for her invaluable support, encouragement and guidance throughout my research trip, and the Best family, for their kindness, hospitality, and especially Riki and Kiran for valuable data on early pilot tests.

I am extremely grateful to all informants who willingly participated in this study. Above all, I would like to express my love and gratitude to all the children and their parents of Fuyō Nursery and Minami Kaidori Primary School for their extraordinary enthusiasm.
and cooperation. Equally, to all those who kindly helped me in coordinating and running the interviews as well as generously offering me their facilities and private homes for recording sessions. Without their generosity, understanding, and support, this thesis would have never been possible: Eiko Kishi, the teachers of Minami Kaidori Primary, Fukueko Ueyama, the teachers of Fuyō Hoikuen Nursery, Akira Maeda of Seya Nishi High, Kōji Itō of Kanagawa Junior High, Tsutomu Satō of Meiji Gakuin University, Tatsuya Sakuma of Fujimidai Junior High, Kaori Iji, Urara Fujishima, Wakaba Suzuki, and all the children and students from these educational institutes. Also, I wish to acknowledge the generous support of: Nami Ajima and Keisuke Fushimi, Natsumi Asaka, the staff at AXA Direct, Charles Aylwin and Yen Ming, John and Yuka Bolland, Yuiko Hasegawa, Akiko and Dominick Haslam, Sanae and Kōichi Honda, Judith Ilett, Genta Inatomi, Yōko and Atsushi Itō, Mark Jeffery, Hiroko Kaneko, Tomoko Kawamura, Nigel Keemer, Ayako Matsuda, Tomoko Maeda, Hiroko Nagaoka, Zenji Mito, Yoshiko Nakatani, Kōichirō Obu, Asako Saitō, Noriko Sakuma, Rious Taiyo, Hirotomo Tanaka, Mayumi Yatsuda, Yoshio and Makiko Takahashi, Mr. and Mrs. Takiguchi, Hiroko Umeda, and all of their families and friends.

Most of all, I wish to express my deepest gratitude and profound respect to Mr. and Mrs. Tsuzuki of Tsuzuki Sōgō Educational Institute. Without their and their family's unflagging support over the many years, both professionally and financially, this thesis, and the chance to complete it would not have been possible. To them, I am eternally grateful.
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List of Notations and Abbreviations

ACC: a rendaku inducing condition: ‘when a compound is accented (a pitch fall)’
Acc: Accusative
AJ: Adjective
AJ-N: Adjectival Noun
AV: Adverb
BCD: Biased Constraint Demotion
CC: Coordinate Compounds
CD: Constraint Demotion
CON: Constraints
CONJ: Conjunctive
Dep[F]: DEPENDENCE (correspondence/faithfulness constraint) ‘no featural insertion’
DMT: Dual-Mechanism Theory
D-O: Direct Object
D-O+P: Direct Object plus Predicate – a rendaku-inhibiting condition: ‘when the noun first element of a compound is grammatically the Direct Object of the Predicate verb second element’.
EVAL: Evaluator
F: Foreign vocabulary (lexical stratum) in Japanese
GEN: Genitive
GEN: Generator
GER: Gerundive
\( \mathcal{H} \): a constraint hierarchy
\( \mathcal{H}_0 \): the initial hierarchy
\( \mathcal{H}_{MF} \): a constraint hierarchy with the [Markedness \( \gg \) Faithfulness] initial state
\( +/h//m/ \): a rendaku inhibiting condition: ‘the second member of a compound consists of the voiceless fricative /h/ and a nasal’
HON: Honorific
IDENT[F]: IDENTITY (correspondence/faithfulness constraint) ‘requires featural identity’
I-O: Indirect Object
IO: Input-Output (faithfulness)
LCC: Local Constraint Conjunction
LL: Lyman’s Law – a rendaku-inhibiting condition: ‘when the second element
List of Notations and Abbreviations

contains a voiced obstruent'

LL2: collective label for a group of subjects in the study who violated Lyman’s Law in a stimulus “soketa + soda” (whose second element is bi-moraic)

LL3: collective label for a group of subjects in the study who violated Lyman’s Law in a stimulus “soketa + tetage” (whose second element is three morae)

LV+: a rendaku-inducing condition: ‘the first member of a compound ending in a Long Vowel’

Lv: the initial grammar

LF: the Full (target) rendaku grammar

LsF: the Strong UNIFORMITY[voice] grammar

LwF: the Weak UNIFORMITY[voice] grammar

M: Mimetic vocabulary class (lexical stratum) in Japanese

MAX[F]: MAXIMALITY (correspondence/faithfulness constraint) ‘no featural deletion’

N: Noun

NON-PAST: Non-Past tense

NOM: Nominative

NP: Noun Phrase

/N+/: a rendaku-inducing condition: ‘the first member of a compound ending in the ‘mora Nasal’

OCP: Obligatory Contour Principle

OCP[F]: OCP for adjacent identical [F] (features)

OCP[+voice, -son]: OCP for voicing of obstruent

OO: Output-Output (faithfulness)

OT: Optimality Theory

P: Predicate

PAST: Past tense

PDP: Parallel Distributed Processing (model)

PRES: Present tense

Pron: Pronoun

ps-J: pseudo-Japanese (words)


PX+: Prefix(ed) compounds – a rendaku-inhibiting condition

RCD: Recursive Constraint Demotion

RBC: Right Branch Condition

rdk: rendaku (‘Sequential Voicing’) .

+rdk: with rendaku (i.e. rdk observed)
List of Notations and Abbreviations

- rdk: without rendaku (i.e. rdk not observed)
+ Rdk: rendaku-inducing
- Rdk: rendaku-inhibiting
RDPY: Reduplicated Yamato compounds (non-mimetic)
RDT: Rule-and-Derivation Theories
REALIZE-MORPHEME: parse the linking morpheme [voice],
RHR: Right-hand Head Rule
ROTB: Richness of the base
SD: Standard Deviation (statistics)
SEQVOI: a linking rendaku [voice], morpheme and a faithfulness constraint that forces the feature to surface
son: sonorant
SU: Subject
TETU: The Emergence of The Unmarked
UG: Universal Grammar
UR: Underlying Form
UNIFORMITY[F]: UNIFORMITY (faithfulness constraint) 'no featural fusion'
UNIFORMITY[voice]-G: 'no voice fusion within a General domain'
UNIFORMITY[voice]-M: 'no voice fusion within a Morpheme'
+[-VF]^2: a rendaku-inhibiting condition: 'when the second element of a compound is a word beginning with two identical syllables containing a voiceless fricative.'
+ VOb: Voiced Obstruent
- VOb: Voiceless Obstruent
VOb+Ob: a rendaku inhibiting condition: 'when the first element of a compound ends with a mora containing a Voiced Obstruent, followed by its voiceless counterpart (Ob) at the beginning of the second element'
voi: voice
*[+voice, -son]: (markedness constraint) 'no voicing of obstruents' (= VOP)
VOP: (markedness constraint) Voiced Obstruent Prohibition ('no voicing of obstruents')
V: Verb
Vi: intransitive verb
VN: Deverbal Nominal
V/N: Verbal Noun
### List of Notations and Abbreviations

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<th>Abbreviation</th>
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<td>V-s</td>
<td>Verb stem</td>
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<tr>
<td>Vt</td>
<td>transitive verb</td>
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<tr>
<td>Y</td>
<td>Yamato (native) vocabulary class (lexical stratum) in Japanese</td>
</tr>
<tr>
<td>Y-J</td>
<td>Yamato-Japanese</td>
</tr>
<tr>
<td>®</td>
<td>a worst case scenario, opaque output, ill-ranked grammar</td>
</tr>
<tr>
<td>+</td>
<td>morpheme boundary</td>
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The hyphen (-) is used in various ways, usually to indicate morphological layers in inflected words, often to show immediate constituency such as affixes, inflectional endings, i.e. *ko-* [ko] ('small'), *kak-u* [kakui] ‘write PRES’. In addition, wherever necessary the morphemes within a word or compound are also separated by a hyphen, e.g. *kosō-koso* [kosokoso] ('sneakingly'). A hyphen is also used to indicate a morpheme or syllable boundary in a sequence of three or more identical vowels, e.g., *kō-on* [ko:on] ('high temperature'). Plus (+) is also used to indicate a morpheme boundary. All Japanese words and names (except quotations and author names that appear in the spellings they use for their own or where the Hepburn system is used) are transliterated in the Kunrei-siki system of romanization. Whenever necessary, this is followed by phonetic transcriptions in square brackets [], based on IPA system. Slant bars // enclose phonemic transcriptions. Glosses (translational equivalents) are enclosed in single quotes enclosed by brackets immediately following phonetic transcriptions. Long vowels are transliterated in two different ways: usually with two vowels (*aa, uu, ee, oo* and *ii*), or with *the macrons* (ā, ū, ē, ō, ī) (with exception of *Tokyo* and *Kyoto*). ‘Moraic nasal glide’ is transliterated with traditional *n*’ if immediately preceding a vowel or glide and with *n* elsewhere.
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There is little doubt that certain morphemic alternations (i.e. changes that occur in morpheme shapes such as verbal inflection) call for specific phonological rules, triggering automatic alternations at the phonetic level. It is known that in Japanese there is a particular morphophonemic phenomenon – traditionally known in Japanese by the technical term RENDAKU (連濁), which is usually translated as SEQUENTIAL VOICING (Martin 1952:48) – which involves a certain morphemic alternation process that manifests as regular phonetic changes of a particular class of segments. As the name suggests, it is a junctural process which refers to ‘voicing’ of the first phonetic segment of the second morpheme element of a compound or a stem-and-affix formation. The segment in question must be a morpheme initial voiceless obstruent of the second element, and it undergoes voicing to become a voiced obstruent. However, it is confined to Yamato (native) vocabulary, and is strictly governed by a systematic phonological constraint known as Lyman’s Law (Lyman 1894; abbreviated as ‘LL’) in which Rendaku is blocked if the second element of a compound already contains a voiced obstruent. Rendaku (henceforth, ‘rdk’ for short) is also affected to a lesser extent by
several other factors such as syntactic (internal structure of a compound), morphological/grammatical factors (class and type of compound elements) and semantic (relationship between compound elements). Thus, in short, rdk is known as a phonological rule of Japanese in which the initial obstruent of the second element of a compound is voiced unless LL blocks the change.

Rdk is quite a common, but also arguably an opaque phenomenon observed in modern Japanese. Controversy over the puzzling nature of rdk is not new; it is an issue which has been frequently acknowledged and debated among language researchers (Japanese and non-Japanese alike). What makes rdk of interest, first of all, is that its origin remains essentially unknown, allegedly hidden in the distant, unrecorded past of the history of the language (Kamei, Yamada and Oto 1963, but see Unger 1975). Secondly, and probably the biggest challenge yet offered to the researchers, rdk is fundamentally an irregular phenomenon with sporadic and lexicalized exceptions and distributional gaps. It does not seem to be an entirely rule-governed phenomenon, yet not all the exceptions are a list of lexicalized items. The attempts that have been made so far – the pioneering and earlier works including Lyman (1894), Kindaichi (1938), Martin (1952), Hamada (1952), Nakagawa (1966), Kindaichi (1967, 1976), Miller (1967), McCawley (1968), Sakurai (1966, 1972), Okumura (1972, 1980), Unger (1975), Ōtsu (1980), Itô and Mester (1986), Vance (1979, 1980, 1982, 1987, 1996) and many others – fully to formalize the conditioning principles behind rdk has not been conclusive. Vance (1979) claims that rdk is essentially a “non-phonologically-conditioned” phonological rule.

Thirdly, rdk voicing and LL have been frequently on the agenda of autosegmental phonology, particularly in the context of Obligatory Contour Principle (henceforth, the
"OCP", Leben 1973) along the line of the developments in Optimality Theory (abbreviated as ‘OT’, Prince and Smolensky 1993; McCarthy and Prince 1993a, b, 1994, 1995). OT has offered probably the most successful analysis of rdk so far (e.g. Itô and Mester 1996, 1998; Fukazawa 1999; Fukazawa and Kitahara 2001). The growing number of studies in the theory has demonstrated that some of the language-peculiar aspects of rdk could be better-explained by attributing them to the interactions between the universally-given constraints. More importantly, OT predictions about learnability and language acquisition have been increasingly acknowledged as empirically superior to those made by traditional rule-based theories. However, the dark side of rdk, namely its irregularity and the impact that has on the language speaker/learner, still remains the biggest obstacle for such theories. Whether or not it is a synchronically ‘alive’ process and to what extent seems highly questionable and is worth investigating.

Empirical observations suggest that not many linguistically naïve native speakers seem aware of the complex nature of rdk, and have little conscious idea of the mechanism involved and the constraints on it. This is hardly surprising because in ordinary life it is neither a particularly common matter nor is it a complex task to make a quick hit-or-miss guess at the reading of, say, someone’s surname: Ta-sima or Ta-zima for the given writing 那島. Similarly, rdk compounds are not an indispensable part of daily conversation like verb inflections, for instance. The difference among speakers in the knowledge they have of rdk has very little effect on the course of ordinary conversation and is not easily detectable. However, it is clear from a simple informal experiment that speakers do have their own idea of when to produce rdk and when not to. When they are asked to invent novel compounds using any words around them, they manage to come up with fairly sensible and plausible utterances on which they all agree.
for one reason: "because it sounds right". This 'sounding right' strategy becomes more attractive and convincing when they claim that they find some rarely used rdk compounds strange, implausible or even totally unacceptable again for the same reason: "not sounding right". When they say 'right' or 'wrong', they mean the degree of 'acceptability' rather than 'possibility'. So, when asked to form a novel compound meaning 'burning paper' (yaki + kami), for instance, it is uncontroversial among speakers that both yaki-kami and yaki-gami are possible words in Japanese; what is controversial is the judgment on which one is more acceptable than the other. This suggests that these speakers seem capable of making use of some kind of generalizations about rdk in producing and perceiving novel compounds (i.e. real words in novel combinations), yet none of them are positively aware of what it really is. Then on what ground do they claim what should be 'right' or 'wrong'? If this 'sounding right/wrong intuition' is a straightforward reflection of speakers' internalized knowledge about rdk, this is an indication that the speakers have 'tacit' knowledge of rdk, and that such information can manifest only when they are asked to tap into their consciousness. Then the key question is; how is rdk represented in the minds of the real speakers, and how do speakers acquire it?

The present study is an attempt to investigate the reality of the rdk phenomenon in the speaker's mind: to see how the mind captures the diversity of rdk as a synchronic phenomenon that is subject to more than a dozen conditioning factors. This is not to claim in the strongest sense that any formal descriptions linguists suggest must correspond to psychological regularities of the speaker, but rather that the generalizations that linguists detect may not necessarily be the same as the generalizations that the speakers internalize. The discussion of research questions and
methods is couched within the framework of the theory of *Universal Grammar*, with particular focus on psychological reality of phonological processes, learnability and language acquisition and development. Two theories, OT and the *dual-mechanism* theory (e.g. Pinker and Prince 1988, 1994; Marcus *et al.* 1992, Marcus *et al.* 1995; Pinker 1999), join forces to gather conceptual/empirical and linguistic/cognitive building blocks in constructing working hypotheses for the acquisition and development of rdk. Chapter Two provides background knowledge and preliminaries on certain aspects of Japanese language, particularly those relevant and important to the analysis to follow. Chapter Three presents major previous work and gives a detailed taxonomy of the conditions known to date. The first half of Chapter Four is dedicated to the formal OT account of rdk in which the motivation behind rdk voicing as well as LL and stratum specificity are attributed to the ranking of relevant constraints. The latter half of the chapter addresses the key question of how rdk could be learned and developed. It highlights the assumptions on learnability and acquisition made by OT upon which hypothetical grammar models are built. On explaining how the irregularity is handled by the speaker, Chapter Five aims to construct learning hypotheses based on the predictions proposed by the psycholinguistic theory of dual-mechanism in morphological representation, production and processing developed in the vigorous debate over the role of symbolic/connectionist models in the speaker’s understanding of the lexicon and grammar, and language learning in general. Taking English past tense inflection as a paradigm example and working model, the interaction between symbolic rules and associative memory is adopted to characterize the regularity/irregularity of rdk as an outcome of such interaction. Some other psychological issues in morphological storage and access are also brought into the discussion. A psychological notion of “rule
"is considered to be the prime source of evidence for the psychological reality of the voicing process. Chapter Six presents a set of hypotheses by applying all the formal and empirical issues reviewed to the case of rdk. The key predictions from the two theories are combined in order to construct an integrated hypothetical model of rdk acquisition in the form of multi-staged development grammars. Chapter Seven describes that this is to be tested by means of series of nonsense-word experiments on 131 linguistically naïve native speakers of Japanese. The study involves different age groups including children as young as three years old. Thus, the results presented in Chapter Eight throw light on whether rdk can be a productive rule-based process and on the process of the acquisition of rdk, suggesting which of the conditions appear as psychologically real tendencies and become available as the subjects grow older. In other words, we will be able to see the manifestation and development process of the rdk-handling strategy along the age span. Finally, Chapter Nine presents certain conclusions on the psychological status of rdk and attempts to explain what constitutes tacit knowledge of rdk, or the sounding right/wrong intuition among native speakers of Japanese. The chapter also deals with how the diversity of this once-regular phenomenon prompts individual speakers to treat the same phenomenon in different ways, resulting in different forms of rdk competence and intuitions. This echoes Smith and Cormack’s (2002) idea that perhaps some parameters may be unset or may be set differently by different speakers of the same language. In OT conception, this means that the relevant constraints for rdk may be unranked or randomly ranked from speaker to speaker.
This chapter concludes with a brief illustration of some basic facts about rdk. Rdk is a phenomenon that occurs in Japanese when two words are put together as in (1). The hyphen (-) indicates a boundary between compound members.

(1) \( ori + kami \rightarrow ori-gami \)

'fold' 'paper' 'paper folding'

When the two words \( ori \) and \( kami \) are combined, the resulting new word is \( ori-gami \), not \( ori-kami \). The change \( k \rightarrow g \) in (1) is the result of rdk. More examples are given in (2).

(2) a. \( ama + tai \rightarrow ama-dai \)

'sweet' 'sea bream' 'tilefish'

b. \( maki + susi \rightarrow maki-zusi \)

'roll' 'sushi' 'rolled sushi'

Here, rdk changes \( t \) into \( d \), and \( s \) into \( z \). It might seem that rdk is a natural process of intervocalic voice assimilation. In fact, rdk always occurs in the environment between two sonorants because of Japanese syllable structure. It is a phenomenon that happens diachronically in many languages, e.g. Latin \( fāta \) 'fate' > Spanish \( fada \). Another example of rdk in (3) adds a slight complication to this account.

(3) \( ike + hana \rightarrow ike-bana \)

'arrange' 'flower' 'flower arrangement'

The peculiar alternation \( h \rightarrow b \) is due to a historical change. \( /h/ \) in Japanese morphophonemically behaves like a bilabial, and is arguably derived from underlying
/p/; its voiced counterpart is /b/. Thus, rdk is seen in the following sets of alternation: /l/ ~ /d/, /s/ ~ /z/, /k/ ~ /g/, and /h/ ~ /b/.

So far, it appears that rdk is a phonological process that changes an initial voiceless segment of the second member of a compound word into its voiced counterpart. What then is interesting about it?

First, it is clear that intervocalic voicing assimilation is not an adequate account of rdk. No such general rule exists in Japanese. The voiceless ~ voiced obstruent pairs in (4) show a voicing contrast between two vowels.

(4)  

<table>
<thead>
<tr>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>asa</td>
<td>'morning'</td>
</tr>
<tr>
<td>mato</td>
<td>'target'</td>
</tr>
<tr>
<td>kaku</td>
<td>'write'</td>
</tr>
<tr>
<td>hoho</td>
<td>'cheek'</td>
</tr>
<tr>
<td>aza</td>
<td>'bruise'</td>
</tr>
<tr>
<td>mado</td>
<td>'window'</td>
</tr>
<tr>
<td>kagu</td>
<td>'sniff'</td>
</tr>
<tr>
<td>hobo</td>
<td>'approximately'</td>
</tr>
</tbody>
</table>

Second, rdk takes account of morphology – it occurs only in a 'compound' or a 'stem-affix' formation. Compare a compound noun (N) and a noun phrase (NP) in (5).

The phrase kono ('Pronoun') kami does not show rdk.

(5)  

<table>
<thead>
<tr>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>kono</td>
<td>'this' (Pron)</td>
</tr>
<tr>
<td>kami</td>
<td>'paper'</td>
</tr>
<tr>
<td>kono kami</td>
<td>'this paper' (NP)</td>
</tr>
<tr>
<td>cf. ori-gami</td>
<td>'folding paper' (N)</td>
</tr>
</tbody>
</table>

The string of formatives always has to be in a structure illustrated in (6). For example, when a word [ A ] is combined with another word [ B ], rdk affects the initial voiceless
consonant of [B].

\[
\begin{array}{c|c}
[A] & [B] \\
\hline
\text{R(endaku)} & \text{e.g.} \ ori + kami \\
\end{array}
\]

However, rdk is systematically blocked if the second element of a compound contains an underlying voiced obstruent anywhere within itself. This restriction is LL mentioned earlier. This is the only phonological condition on rdk that has no exception. Examples are given in (7). Note that in (7-b) the voiced obstruent is in the third mora of the second element.

\[(7) \quad \begin{align*}
\text{a. } & \text{yaki} + \text{soba} \rightarrow \text{yaki-soba} & \ast \text{yakizoba} \\
& \text{‘fry’ ‘noodles’ ‘fried noodles’} \\
\text{b. } & \text{yude} + \text{tamago} \rightarrow \text{yude-tamago} & \ast \text{yude-damago} \\
& \text{‘boil’ ‘egg’ ‘boiled egg’}
\end{align*}\]

For a longer compound of more than two members, its internal structure determines the occurrence of rdk. Compare the two compound structures (8) and (9) below. The numbers indicate the order of compounding.
In (8) all the right-branching members in both compound structures undergo rdk, whereas in (9) below where a compound has a left-branching structure, only the right-most member undergoes rdk.

Third, rdk is restricted to certain classes of morphemes. In Japanese, four different morpheme classes are recognized: **Yamato** (native Japanese), **Sino-Japanese** (descendants of old Chinese borrowings), **Foreign** (recent non-Chinese borrowings) and **Mimetic** (‘onomatopoeic’; a rich store of ideophones including reduplicated items, e.g. kata-kata ‘rattle-rattle’, hara-hara ‘feeling uneasy’). Rdk affects only Yamato items and a handful of Sino-Japanese second members despite the fact that both members of a compound can come from all the classes. This is demonstrated in (10) below (N.B. ‘Y’):
Yamato; ‘S-J’: Sino-Japanese; ‘F’: Foreign; ‘M’: Mimetic)

(10) a. siro (Y) + sake (Y) → siro-zake
    ‘white’ ‘rice wine’ ‘sweet white sake’

cf. kan (S-J)-zake (Y) ‘warmed sake’

b. siro (Y) + satoo (S-J) → siro-zatoo
    ‘white’ ‘sugar’ ‘white sugar’

cf. kaku (S-J)-zatoo (S-J) ‘cube sugar’

c. siro (Y) + taku (F) → siro-taku
    ‘white’ ‘taxi’ ‘unlicensed taxi’

cf. rin (S-J)-taku (F) ‘pedicab’

d. niko-niko (M) + kao (Y) → nikoniko-gao
    ‘beaming’ ‘face’ ‘smiling face’

cf. maru (Y)-gao (Y) ‘round face’

e. ton (M) + kati (M) → ton-kati
    ‘tok’ ‘tick’ ‘hammer’

cf. ton-ton (M) ‘toktok’, kati-kati (M) ‘ticktick’

What is important here is that irrespective of the class of the first elements, rdk is observed only in the Y and S-J morphemes that appear as the second members (10a, b, d). F second members do not show rdk (10c). Note that reduplicated M compounds can appear as the first (predicate) element in a limited number of hybrid compounds such as (10d). Instances like (10e), in which two different M items form a non-reduplicated compound, are very rare. The most common type is reduplicated compounds, such as
ton-ton and kati-kati, and rdk never appears in M second members.

We have seen that rdk is not simply a voicing assimilation process; it is rather a phonological process but crucially governed by several morphological factors. First, it has to be in a compound or a stem-affix formation; second, the second element of such formation must not contain a voiced obstruent in order for rdk to apply (LL); third, it has to take account of the internal structure of a compound; and finally, morphemes must be Y (and only rarely S-J). However, as we will see later in Chapter Three, there are many instances where rdk happens to be absent for some reason even though the required factors are present. It has been claimed by those who have investigated the phenomenon in great detail that it is largely unsystematic and idiosyncratic. As Vance (1987:148) states: “the fundamental irregularity of sequential voicing remains a fact of modern standard Japanese”.
2.1. Modern Standard Colloquial Japanese

The major part of the thesis concerns a synchronic account of modern standard colloquial Japanese. Conventionally, it is known as kyootuugo ‘common language’ i.e. what we expect to hear from the state broadcasters or see in national newspapers and school textbooks. Although it is predominantly based upon Tokyo ‘uptown’ Japanese (i.e. originally, the speech of the educated upper- and middle-class natives of the western region of Tokyo proper called Yamanote), it permits certain minor dialect traits that have been regarded as commonly acceptable or widely used (e.g. accentual features) so as to be learnt and used by dialect speakers in communication with speakers of other dialects including Tokyo. (e.g. Kindaichi 1966; Shibatani 1990). In order to test for a fairly homogeneous group of native speakers of Japanese, subjects for the study were chosen from speakers of Tokyo Japanese, characteristically the closest local speech to modern standard colloquial Japanese.
Tokyo Japanese has five simple vowels; /u/, /o/, /a/, /e/, /i/. The close back vowel /u/ tends to be an unrounded [ɯ]. The most orthodox analyses of phonemic inventories of Tokyo Japanese posit nine obstruent phonemes, namely /p/, /b/, /t/, /d/, /s/, /z/, /k/, /g/ and /h/ as shown in the next section.

2.2. Voicing Alternations of Rdk

First, the consonants of Tokyo Japanese (based on Vance 1987; Nakajô 1989; Okumura 1988; Amanuma, Ōtsubo and Mizutani 1989; Shirota 1995; Kubozono 1998a, b; Imada 1999) are listed in Table 1 below.

Table 1. Summary of Consonants of Tokyo Japanese

<table>
<thead>
<tr>
<th>Bilabial</th>
<th>Alveolar</th>
<th>Alveolo-palatal</th>
<th>Palatal</th>
<th>Velar</th>
<th>Uvular</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plosive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>p b t d</td>
<td>c</td>
<td>k g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap/Flap</td>
<td>m n (η)</td>
<td>(η)</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fricative</td>
<td>(ɸ) s z</td>
<td>(c z)</td>
<td></td>
<td></td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>(ts dz)</td>
<td>(tç dz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximant</td>
<td>j w</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.B. Where symbols appear in pairs, the one to the right represents a voiced consonant. Symbols in brackets indicate allophonic variations.

The voiceless obstruents susceptible to rdk voicing are /t/, /s/, /k/ and /h/. The voicing alternations in rdk are summarized in (11) below. Each column lists allophones with
transcriptions.

\[(11) \quad /t/ \rightarrow /d/ \quad /s/ \rightarrow /z/ \quad /k/ \rightarrow /g/ \quad /h/ \rightarrow /b/\]

- \(ta \ [ta] \rightarrow da \ [da]\)
- \(sa \ [sa] \rightarrow za \ [za]\)
- \(ka \ [ka] \rightarrow ga \ [ga]\)
- \(ha \ [ha] \rightarrow ba \ [ba]\)
- \(ti \ [tɕi] \rightarrow di \ [dʑi]\)
- \(si \ [ɕi] \rightarrow zi \ [ʑi]\)
- \(ki \ [ki] \rightarrow gi \ [ɡi]\)
- \(hi \ [ɕi] \rightarrow bi \ [bi]\)
- \(tu \ [tsu] \rightarrow du \ [dzu]\)
- \(su \ [su] \rightarrow zu \ [zu]\)
- \(ku \ [ku] \rightarrow gu \ [ɡu]\)
- \(hu \ [ɸu] \rightarrow bu \ [bu]\)
- \(te \ [te] \rightarrow de \ [de]\)
- \(se \ [se] \rightarrow ze \ [ze]\)
- \(ke \ [ke] \rightarrow ge \ [ɡe]\)
- \(he \ [he] \rightarrow be \ [be]\)
- \(to \ [to] \rightarrow do \ [do]\)
- \(so \ [so] \rightarrow zo \ [zo]\)
- \(ko \ [ko] \rightarrow go \ [ɡo]\)
- \(ho \ [ho] \rightarrow bo \ [bo]\)

The coronal obstruent /t/ is palatalized before /i/, and affricated before /u/. The peculiar allophonic realizations of /p/ have been a matter of controversy in Japanese phonology. Historically, the labialization is known to be the result of a change (/p/ \(\rightarrow [ɸ] \rightarrow /h/\)). This evolution was partially arrested at the stage of [ɸ], where [ɸ] still remains before /u/. A derivational phonological account (McCawley 1968:77-80) is that the underlying /p/ is converted to [h] in word-initial position (i.e. /pana/ \(\rightarrow [hana]\) ‘flower’, /ike + pana/ \(\rightarrow [ikebana]\) ‘flower arrangement’), and appears allophonically as palatal [ɕ] before /i/ and bilabial [ɸ] before /u/. Whereas the voiced counterpart is uniformly [b]. The most recent account comes from the OT framework that any [p] that is exclusively linked to onset position is ruled out and delabialized to give rise to [h] by the voiceless labial restriction (‘NO-P’) operating only in the Y and S-J vocabularies. By adding a voicing feature, rdk gives rise to [h] \(\sim [b]\) alternations (Itô and Mester 1999). For the remainder of the study, this alternation specific to Y and S-J strata will be written as /h/ \(\sim /b/\) or /h/ \(\rightarrow /b/\).

The voiceless /t/ and /s/ have palatalized and affricated realizations, and their voiced counterparts /d/ and /z/ show a similar pattern: [ta], [tɕi], [tsu], [te], [to] become [da], [dʑi], [dzu], [de], [do], and [sa], [ɕi], [sui], [se], [so] become [za], [dʑi], [zui], [se], [so].
[dzu](zu), [ze], [zo] respectively. Here [dzi](zi) and [dzu](zu) are shared by both cases. In other words, the phonemic sequences of both /di/ and /zi/ are realized as [dzi](zi) phonetically, and /du/ and /zu/ are realized as [dzu](zu). Historically, /di/ had been [di] and /zi/ had been [zi] until the fourteenth century when the ‘affrication shift’: [ti] > [tsi]; [di] > [dzi]; [tu] > [tsu]; [du] > [dzu] took place yielding the contrasts between [dzi]/[zi] and [dzu]/[zu] (instead of the previous [di]/[zi] and [du]/[zu]) (Komatsu 1981:119-128). These contrasts probably had already been lost by the sixteenth century in the Tokyo area, merged and neutralized in the pronunciation of most Japanese people (see Toyama 1972; Vance 1987; Shibatani 1990).

The modern Japanese writing system needs explanation as its kana orthography provides a ‘visual’ clue of the voiceless ~ voiced alternations. Japanese has a set of moraic symbols, known as kana, used to represent purely phonetic values of a moraic unit. The Y vocabulary may or may not be written in kanji, or Chinese characters (ideophones), but there are words, mainly grammatical elements, for which kanji cannot be used. For example, origami (‘folding paper’) is a Y compound consisting of two Y morphemes, ori (‘folding’) and kami (‘paper’). The first element is written 折り (a kanji and a kana), and the second 紙 (one kanji), and the compound origami is 折り紙. It is also possible to write using only kana: ori as おり (two kanas), kami as かみ (two kanas) and origami as おりがみ. The four kana symbols read ori-ga-mi indicating how the word is pronounced. Note that in the second element of おりがみ, the initial voiced obstruent [ga] has two dots called dakuten (i.e. “the voicing dots”) in its upper right portion. This indicates the relationship between the voiceless か [ka] and its voiced

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1 Certain dialects still maintain the distinctions (Shibatani 1990:165). In the Köti dialect, spoken in the south eastern part of Sikoku island, /zi/ and /du/ are realized as [zi] and [di]. Some dialects of Kyūshū, southern part of Japan, are known to distinguish [zi] from [dzi].
counterpart ʰ̄ [ga]. This holds for all the obstruent pairs including the rdk-peculiar [h] ~ [b] as in ḡ [ha] and ḷ [ba]. The implication is that since the voicing alternation is visibly recognizable when a form is written in kana, but not when it is written in kanzi, pre-school children who normally learn to read and write new words first through kana may have a greater chance of learning the rdk alternation as part of the knowledge of orthography as well as that of phonology. In addition, some children start learning the 5×10 kana chart (normally shows only the sonorants and voiceless obstruents) as young as the age of three, and some parents and nurseries teach how to read the voiced obstruent series. Even without explicit teaching, most children by the age of four seem to become able to read all or most of the kana syllabaries including the ‘dotted’ ones. The early mastery of /h/ ~ /b/ alternation implies that for most native speakers it may not be as peculiar as it seems.

2.3. Lexical Organization

Conventionally, the Japanese lexicon is classified into four different morpheme classes: Yamato or native (‘Y’), Sino-Japanese (‘S-J’), Foreign (‘F’) and Mimetic (‘M’). The Y vocabulary is a class of the modern descendants of morphemes that was presumably part of the Japanese vocabulary before around 400 AD when the first borrowings from Chinese began. S-J vocabulary consists of the modern descendants of morphemes that were borrowed from Chinese in three major waves during 5th, 8th and 14th centuries. These morphemes are syntactically distinct from other Japanese morphemes in that they mostly function as bound morphemes to form two-element compounds, constituting the
extensive technical vocabulary. One major way of differentiating the Y and S-J morphemes is the writing system. The S-J words are normally written in kanji, although hiragana can be used to indicate how it is read.

The F vocabulary is a class of recent borrowings other than Chinese. These morphemes are typically written in katakana (square kana) syllabaries. Although the vast majority of these have been borrowed from English in this century, a few others have already entered Japanese since 16th century; since these words have become so well integrated that they are often written in hiragana as well as katakana.

The M vocabulary is a substantial class of sound-symbolic/onomatopoeic items or 'ideophones'. They are involved not only in the system of sound symbolism but more importantly in the overall system, as they function syntactically as manner adverbs and may refer to just any aspect (visual, emotional, etc.) of the activity involved, rather than just its sound.

2.4. Productivity and Frequency

Before taking up some morphological issues relevant to rdk, it is important to define three of the key notions in the current study: productivity, semi-productivity and frequency. The notion of productivity is one of the most debated areas in the study of phonology, syntax, and most of all, morphology. It generally refers to a feature of a particular (morphological) process. The term is fairly ambiguous, and used in different ways by different scholars. Rainer (1987), reproduced in Bauer (2001:25), claims that there are six types of definition of productivity current in the literature:
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(a) a definition in terms of the frequency of the output words.
(b) a definition in terms of the number of available bases, that is in terms of the frequency of the input category (Lieber 1981:114-115).
(c) a definition in terms of the proportion of words actually used to the number of potentially created by a particular process (Aronoff 1976; Al and Booij 1981).
(d) a definition in terms of the possibility of forming new words.
(e) a definition in terms of the probability of new forms occurring (Harris 1951:374-375; Aronoff 1983:163).
(f) a definition in terms of the number of new forms occurring in a specified period of time.

(Bauer 2001:25)

As it will become clearer in Chapter Five, the ‘productive application of rdk’ is the prerequisite for the evidence for psychologically real phonological process of the speaker’s core grammar. Therefore, the definition of productivity in the current study is closest to (d), (e) and perhaps (f) above. Baayen (1994:447) defines as “the ability of speakers to coin, without any apparent conscious effort, new morphologically complex words”; Badecker and Caramazza (1998:399) argue that “productivity is the measure of a speaker’s capacity to employ a particular word formation rule in order to add new forms to the set of meaningful words.” Anshen and Aronoff (1998:242-3) give a definition “informally as the extent to which a particular affix is likely to be used in the production of new words in the language. On this view, productivity is a probabilistic continuum that predicts the use of potential words”. Jackendoff (1997:115) explains, by taking the English plural as an example, that “given a count noun, the speaker automatically knows that it has a plural form and what that form means. The speaker also knows that it has a default value for its pronunciation, which can, however, be
blocked by learned irregular cases.” By taking up all the ideas raised above, Bauer (2001:32) concludes that frequency, semantic coherence (i.e. transparency and opacity) and the ability to make new words seem to be prerequisites for (morphological) productivity rather than productivity itself. Cutler (1980) implies that morphological processes which retain transparency are more productive than those which do not. It seems that transparency is, if not a prerequisite for productivity, at least a major encouragement to productivity. As we will see later in Chapter Five, the psychological notion of default joins the prerequisites for a process being ‘regular’, ‘productive’ and ‘rule-governed’.

It is commonly considered that there is a continuum (or degrees) of productivity, and this is supported by a fair amount of empirical evidence. Somewhere intermediate along the full-productivity ~ un-productivity scale lies the notion (degree) of semi-productivity. Jackendoff (1997:115) defines that in a case of semiproductive regularity, “we don’t know exactly what the output of the rule is in a particular case.” Pinker and Prince (1994:231) simply state that a process is semiproductive when it “can to some degree be extended to new forms”. The conceptualization of semiproductivity is also a contested issue, but the point here is that not all word formation processes are either fully-productive or unproductive.

Frequency is an important concept related to productivity, but many linguists argue that it is a mistake to equate frequency and productivity. As we have seen in the previous sections that two notions of frequency must be distinguished:

(i) Type frequency (‘lexical frequency’): “refers to the number of different words in a class, each counted once” (Marcus et al. 1995:212); “items in the language that contain the item or process under consideration” (Bauer 2001:47);
(ii) *Token frequency* ('text frequency'): "refers to the number of occurrences of a word" (Marcus *et al.* 1995:212); "the number of times a particular item occurs in a given text" (Bauer 2001:47).

It is not uncommon that a morphological process, which appears to be productive, does not give rise to many new words. Furthermore, there are instances where a particular morphological process has a high-type frequency, but appears not to be productive. Type frequency is the result of past productivity rather than an indication of present productivity. We will see plenty of evidence that high token frequency plays an important role in various morphological learning.

### 2.5. Compounds

A *compound* is a lexical item consisting of more than one existing lexical element. It has a complex morphological composition, but the top (parent) node is always a lexical category and thus shows the same distribution as a lexical category. Compounds are different from prefix + stem formation in that they typically consist of more than one stem or root, a lexical rather than grammatical element. They have the characteristics of both 'syntactic' and 'lexical' expression: syntactic in the sense that the members exist independently as words, and the resulting unit is a word (Bybee 1985:105-6). We will examine the structure and semantics of Japanese compounds in detail later in 2.5., and this section focuses on the types of compounds and the notion of *head* which is crucial in characterizing the semantics of compounds. The syntactic properties of compounds
can be described in terms of tree structures, one member playing a crucial role in the inheritance of syntactic properties such as word class. In some languages, including Japanese, compounds inherit these properties from their rightmost constituent called the head (e.g. Williams 1981b; Selkirk 1982). Williams (1981b:248) proposes the following rule (12) that specifies the head of a word structure.

(12) **Right-hand Head Rule (RHR)**

In morphology we define the head of a morphologically complex word to be the right-hand member of that word.

In order to cater for left-headed components (e.g. verb-particle sequences in English), Selkirk (1982:20) proposes a revised version of the rule as the following:

(13) **Right-hand Head Rule (revised)**

(N.B. P and Q stand for individual category symbols)

In a word-internal configuration,

![Diagram]

where X stands for a syntactic feature complex and where Q contains no category with the feature complex X, $X^m$ is the head of $X^n$.

Compounds then can be classified using two criteria (Katamba 1993:304):
(i) whether they have a head

(ii) if they have a head,
   a. the word-class of the head
   b. whether the head appears at the left or at the right of the compound

The RHR is not universal. For example, Italian compounds normally are left-headed, and so are some Japanese S-J compounds and prefix + stem structures (e.g. Kageyama 1982).

Compounds which have a head (i.e. 'headed' compound) are called endocentric compounds. Semantically, a head of a compound denotes the core meaning of the whole compound, and the class of elements denoted by the compound is a subset of the class of elements that would be denoted by its head. In general, the non-head constituent of the compound further defines or modifies the head, but in many cases, the semantic relation can vary significantly. One well-known exception to this is a class of compounds called verbal (or synthetic) compounds that have the following characteristics (Katamba 1993:308; Italics/bold original):

(i) a complex head adjective or noun, which is derived from a verb;

(ii) the nonhead constituent is interpreted as a syntactic argument of the deverbal noun or adjective head;

(iii) the θ-role of the nonhead is that of agent, patient, etc.;

(iv) the meaning of the compound is transparent.
Chapter 2 — Preliminaries

The ‘θ-role’ specifies a semantic relationship between a predicate and its arguments, such as agent, patient, instrument, theme, and so on (see Katamba 1993:256-264). Not all languages have synthetic compounds. Japanese, as well as English does, but French, for example, does not. Examples of verbal compounds from English (Fabb 1998:68) and Japanese are given below (detailed discussion appears in 2.6.4.):

\textit{window-clean-ing} \quad [\text{Noun-verb-ing}] = 'clean' \nu 'window'

\textit{meat-eat-er} \quad [\text{Noun-verb-er}] = 'eat' \nu 'meat'

\textit{yasai-itame} \quad [\text{Noun-verb-stem}] = \textit{yasai o itame-ru} ('vegetable'-Acc 'fry'\nu)

'fried vegetable'

\textit{mono-tori} \quad [\text{Noun-verb-\~}] = \textit{mono o tor~u} ('property'-Acc 'rob'\nu)

'thief'

Note that the semantic argument-structure of these compounds is systematic, transparent and matches that of the syntax of the compound. For example, \textit{meat-eater} is an eater (agent) of meat (theme); similarly, \textit{mono-tori} is a robber (agent) of someone’s property (theme). In both cases, the first elements act as the direct objects of the verbs in such syntactic phrases, and the constituents stand in ‘argument-predicate’ relationship. Note, however, that the lack of clear suffixes in ‘deverbal’ nominal – verbs-from-nouns – compounds in Japanese gives rise to a wide range of semantic ambiguity, taken up later in 2.6.4; for detailed transformational analysis, see Sugioka (1986:79-113). For detailed analyses and discussions of verbal compounds, see Roeper and Siegel (1978), Selkirk (1982), Lieber (1983) and Spencer (1991).

When a compound is semantically (although syntactically it obeys RHR) headless it is exocentric. Exocentric compounds are also known by their Sanskrit name of
‘bahuvrihi’ in which one element modifies the other and the whole denotes an entity which is a hyponym of an unexpressed semantic head. That is, the argument structure of its elements does not have a modifier-head relationship. For example, *redhead* is not a head which is red, but rather someone or something having a red head. Typically, their meanings are ‘opaque’, treated more or less like idioms. Because the head of a compound generally specifies “what kind of thing” a compound refers to, bahuvrihi (headless) compounds that have no transparent meaning relation with their constituents (or that are semantically related to only one element) are considered semantically opaque. One type of exocentric compounds are *copulative* (i.e. conjoined, coordinated) compounds, or *dvandva* compounds in Sanskrit. They typically have two coupled elements that have equal status, and are regarded as headless semantically. A few examples from in English (Katamba 1993:321) and Japanese are shown below. Dvandva compounds are more frequent and widely-used in Japanese.

- *boyfriend*
- *tosi-tuki* (‘years and months’)
- *north-west*
- *uri-kai* (‘selling and buying’)
- *Harper-Collins*
- *Mitui-Sumitomo* (company name)

2.6. Compounds and Derivatives in Japanese

We have seen briefly in the previous sections that rdk is most frequent in compounds in the Y morpheme class. This section looks more specifically at the rdk environment in
terms of morphology. What is directly relevant here is first, the type of grammatical/semantic relations of particular morphological structures in which rdk takes place, and second, the morpheme class of the second element of such structures which are affected by rdk. Two types of structures: compounds (including those with -soru verb) and prefix + stem/base formations are investigated.

2.6.1. Preliminaries

Compounding in Japanese is a particularly common, productive process, and exhibits various grammatical/semantic structures by combining morphemes from all different lexical categories: nouns (N), verbs (V), adjectives (AJ) as well as unique ‘adjectival nouns (AJ-N)’ and ‘verbal nouns (V/N)’ (so termed by Martin 1975). The latter two categories are characterized by their dual status: AJN stems are nominalized by the suffix -sa, as are genuine AJ stems, but are inflected differently and behave syntactically as nouns in certain syntactic environments. V/Ns can become (transitive or intransitive) finite verbs by taking the verb -soru ‘do’, but also nouns by taking case particles, for example. The majority of V-Ns are S-J ‘binoms’ (i.e. words written with two kanzi; see Vance 1996) such as a noun ryo-koo (旅行) (‘traveling’) vs. a verb ryokoo-soru (‘traveling-do-NON-PAST’) but also include a few Y deverbal nouns (i.e. nouns-from-verbs) and loan words. The second element of a compound can come from any of these categories: N, V, AJ, AJ-N or V/N. The righthand position of functional heads in compounds is the predominant pattern of Japanese, and it follows that the lexical category of the second element determines the lexical category of the whole
entity (however, there are some counterexamples to this rule in Japanese: prefix + stem/base formations and a few S-J binoms). To illustrate how different categories of morphemes can be compounded in Japanese, some examples with their first elements being a noun are shown in (14).


a. N + N: buta-ziru ‘pork-soup’ = ‘pork soup (N)’  
b. N + V:  ura-gaesu ‘back/inside-turn’ = ‘turn over (V)’ 
c. N + V:  tume-kiri ‘nail-cutting’ = ‘nail clipper (N)’  
tume-asobi  ‘water-playing’ = ‘playing with water (N)’
haru-garu  ‘body-light’ = ‘nimble (AJ-N)’
g. N + V/N: kaigai-ryokoo  ‘abroad-traveling’ = ‘travel abroad (N)’

Some of these constructions need explanation. In (14-b) the second element -gaesu (V) is a non-past tense form of a verb kaes-: the root kaes- (the initial k → g is the result of rdk) and the inflectional NON-PAST ending -u, and the resulting compound is a verb (V). In (14-c) kiri is also a verb but it is in a ‘nominal’ form: the verbal root kir- plus -i, and the resulting compound is a noun (N). This is referred to as deverbal nominal (‘VN’), i.e. nouns derived from verbs (this should not to be confused with V/N: verbal noun), which will be taken up later in detail in 2.6.4. in relation to the semantics of Japanese compounds, and 3.4.6. in relation to rdk). The same contrast holds for adjectives in (14-d) and (14-e): -zamui (the initial s → z is the result of rdk) consists of adjectival root samu- and NON-PAST -i (all the adjectives in non-past forms contain this ending), and the
result of compounding is an adjective (AJ). In (14-e), however, *ita* in and *-garu (-karu)* in (14-e) are adjective ‘nominal’ stems whose use is confined to compounding and reduplication, *e.g.* *karu-garu* (‘effortlessly’). Hence, the resulting compounds fall into a noun category, either nouns (N) or adjectival nouns (AJ-N).

The first elements can be V-s, AJ-s, AJN-s, V/N, as well as N and very rarely adverbs (AVs), *e.g.* *hisohiso-banasi* [AV+N] (‘whispered conversation’), *yotiyoti-aruki* [AV+V-s] (‘toddling’). AVs do not appear as the second elements in compounds, and there are no [AJ+AJ], [AJ-s+AJ], [AJ+AJ-s], [V+AJ-s] compounds in Japanese (Hinds 1986: 378-382).

### 2.6.2. Compounds

Compounds of interest for our present purposes are those with second elements that are susceptible to rdk. These are Y compounds in (15-a) below, S-J compounds (15-b), Hybrid compounds (15-c) – (15-g) including compounds with *-suru* verb (15-d). Note that only a few limited S-J words like (15-b, e, g) are affected by rdk.

(15) Y, S-J and Hybrid compounds

<p>| | | | |</p>
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<thead>
<tr>
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<tbody>
<tr>
<td><strong>a.</strong></td>
<td><strong>Y</strong> + <strong>Y:</strong></td>
<td><strong>buta-ziru</strong></td>
<td>‘pork-soup’ = ‘pork soup’</td>
</tr>
<tr>
<td><strong>b.</strong></td>
<td><strong>S-J</strong> + <strong>S-J:</strong></td>
<td><strong>kaku-zatoo</strong></td>
<td>‘square-sugar’ = ‘sugar cube’</td>
</tr>
<tr>
<td><strong>c.</strong></td>
<td><strong>S-J</strong> + <strong>Y:</strong></td>
<td><strong>kaku-gari</strong></td>
<td>‘square-haircut’ = ‘crew cut’</td>
</tr>
<tr>
<td><strong>d.</strong></td>
<td><strong>S-J</strong> + <strong>Y:</strong></td>
<td><strong>kan-zuru</strong></td>
<td>‘sense-do’ = ‘to feel’</td>
</tr>
<tr>
<td><strong>e.</strong></td>
<td><strong>Y</strong> + <strong>S-J:</strong></td>
<td><strong>kakure-ga</strong></td>
<td>‘hiding-house’ = ‘hideout’</td>
</tr>
<tr>
<td><strong>f.</strong></td>
<td><strong>F</strong> + <strong>Y:</strong></td>
<td><strong>pen-dako</strong></td>
<td>‘pen-callus’ = ‘callus on the middle finger’</td>
</tr>
<tr>
<td><strong>g.</strong></td>
<td><strong>F</strong> + <strong>S-J:</strong></td>
<td><strong>takusii-gaisya</strong></td>
<td>‘taxi-company’ = ‘taxi company’</td>
</tr>
</tbody>
</table>
S-J words need attention here. The crucial difference between Y and S-J compounds is that the latter are formed at the morpheme level. Typically, S-J words come as either single morpheme (15-e) or two morphemes (15-b, g). The latter is known as a binom (i.e. S-J words written with two kanzi; see Vance 1996). Etymologically, these words were formed in Chinese and have been imported as complete words (although there are a fair number of recent Japanese creations). However, such words have an equivocal morphological status, since each constituent of a S-J compound mostly functions as a bound morpheme which does not usually stand for any individual Japanese word on its own. In this respect, such binoms are certainly words but not exactly compounds, and probably should not be called compounds. The remaining chapters will distinguish a binom from genuine S-J compounds such as (15-b) in which two S-J words are combined.

In many S-J binoms, a voiced obstruent at the beginning of the second element is historically the result of rdk (Vance 1996). The voicing of 子 si in 王子 oo-zi (‘prince’) is due to rdk developed within Japanese (cf. 嶽子 yoo-si ‘adopted child’), for example. The voicing contrast in a pair like 告示 koku-zi and 黙示 moku-si, however, is not due to rdk in Japanese but a mere reflection of the differences in the original pronunciations (or hondaku: ‘original voicing’ opposed to rendaku: ‘sequential voicing’) as borrowed from Chinese. The modern kana spellings have lost etymological distinctions of rdk in such binoms. It is highly unlikely that an ordinary speaker is capable of making this distinction. Even a historical linguist will have to consult sources that distinguish the two. Vance (1996:26-7) argues that instances of historical rdk are no longer recognized as synchronic rdk, and should not be treated as rdk in a synchronic
analysis of modern Japanese. We will adopt Vance's view in the remaining chapters.

Note (15-d) that when the verb -suru 'do' is preceded by S-J morphemes of the type X-suru, where X stands for a single monomorphemic S-J verbal element, it constitutes a compound verb. As we will see in the next chapter, rdk occurs frequently when X ends in a long vowel or in a nasal.

2.6.3. Prefix + stem/base formations

Japanese has a rich stock of prefixes, but it is often difficult to determine whether these are really prefixes or bound morphemes for compounding due to the dubious status of S-J bound morphemes like dai- ('big'), syoo- ('small'), sin- ('new') and hon- ('this') which are highly productive (e.g. Shibatani 1990: 218). There are not many Y prefixes, and only a limited number capable of affecting a meaning-change appear in rdk environments. The commonest of these are ko- ('slight-'), oo- ('big-'), huru- ('old-') and su- ('bare-') exemplified in (16). The first three are quite productive but su- is not.

(16) Yamato prefixes:

a. ko- + katana (Y) → ko-gatana 'small-sword' = 'small knife'
b. oo- + kuti (Y) → oo-guti 'big-mouth' = 'big mouth'
   + syotai (S-J) → oo-zyotai 'big-household' = 'big family'
c. huru- + tanuki (Y) → huru-danuki 'old-badger' = 'wise veteran'
d. su- + te (Y) → su-de 'bare-hand' = 'bare hand'

S-J prefixes on the other hand are generally much more productive and larger in
number than Y prefixes (see Nomura 1973 for more examples). In general, they are attached to either S-J morphemes, words and compounds (in some cases), depending on productivity, but we will look at a couple of them that can be attached to Y words. They are *dai-* ('big'), *hon-* ('this, real'), *hu-* ('un-') and *mu-* ('-less'). Among those, as given in (17), no words with *dai-* ‘big’ show rdk.

(17) S-J prefixes:

a. *dai* + *kirai* (Y) → *dai-kirai* ‘big-dislike’ = ‘loathe’
b. *hon* + *kimari* (Y) → *hon-gimari* ‘real-decision’ = ‘final decision’
c. *hu* + *soroi* (Y) → *hu-zoroi* ‘un-even’ = ‘uneven, irregular’
d. *mu* + *sirusi* (Y) → *mu-zirusi* ‘label-less’ = ‘unlabeled’

### 2.6.4. Argument structures of Japanese compounds

The issue of semantic transparency of Japanese compounds is a challenging one. As we can see in (18) below, the semantic and syntactic relationships between the two members are often hard to predict. Among Y compounds (i.e. Y-stem + Y-stem), rdk typically occurs in a formation that is ‘endocentric’: the members of a formation have to stand in ‘modifier-head’ relation. Exocentric compounds such as M and coordinate compounds, bahuvrihi compounds and some deverbal compounds (i.e. nouns-from-verbs) do not show rdk (see 3.4.6.). Deverbal nominal compounds, which are the most numerous type in Japanese, show an ‘adjunct-predicate’ relationship between their first and second members. ‘Adjunct’ is defined as: “a category which is a modifier of a lexical head without being subcategorized for by that lexical head and
which could in principle be removed without affecting well-formedness; e.g., in the sentence *I saw Lisa in the park yesterday*, the phrases *in the park* and *yesterday* are adjuncts of the verb. (Trask 1993:8)" This is contrasted with rdk-avoiding deverbal compounds in which the two members stand in the ‘argument-predicate’ relationship. ‘Argument’ is “a noun phrase bearing a specific grammatical or semantic relation to a verb and whose overt or implied presence is required for well-formedness in structures containing that verb. Arguments may be identified either in terms of grammatical roles (Subject, Direct Object, etc.) or semantic roles (Agent, Patient, etc.). (Trask 1993:20)” An example of this contrast in rdk is taken up separately in (31) below (3.4.6.).

For an illustration, let us look at the possible range of deverbal compounds. A deverbal nominal form of a verb is notated as ‘VN’ and a deverbal compound as ‘[X+VN]’, in which X, the first element, denotes a lexical category. Sugioka (1986:79-80), reproduced below in (18), classifies them by the meaning of the compound and the function of the first element (the list is not exhaustive). It should be noted that, as Sugioka (1986) points out, “the basic nominal form of a verb is the same as the infinitive (adverbial) form in Japanese: verb root + i, or when the root ends with e, i, no overt suffix is added. This form participates in various productive compound formations as a nominal as well as in syntactic environment as an infinitive” (p77). As we can see in (18) below, it is hard to determine whether a particular form is nominal or infinitive, although this issue bears little significance on the current analysis of rdk. (N.B. DO: direct object, IO: indirect object, SU: subject, Vt: transitive verb, Vi: intransitive verb)
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(18) Types of [X+VN] compounds (Sugioka 1986:79-80; N.B. examples indicated by ‘+’ are from Kageyama 1982)

A. Agent
   a. DO: mono-tori (thing-rob) ‘thief’
       kane-moti (money-own) ‘wealthy person’

B. Instrument
   a. DO: nezi-mawasi+ (screw-turn) ‘screw driver’
       kan-kiri+ (can-cut) ‘can opener’

C. Result / Product
   a. DO: yasai-itame+ (vegetable-fry) ‘fried vegetable’
   b. SU (Vt): musi-kui+ (bug-eat) ‘a hole in cloth, etc. caused by a bug eating it.’
   c. SU (Vi): mizu-tamari+ (water-accumulate) ‘puddle’
   d. by-Agent: musi-sasare (bug-be stung) ‘bug sting’
   e. Instrument: kami-zutumi+ (paper-wrap) ‘something wrapped with paper’

D. Place / Time
   a. DO: mono-hosi (thing-dry) ‘a veranda for hanging laundry’
   b. SU (Vi): hi-gure+ (sun-set) ‘sunset (time)’

E. Act (-suru) / Event (-ni naru ‘become’, -ga aru ‘there is ~’)
   a. DO: kane-mooke+ (money-profit) ‘making profit’
   b. SU (Vi): yama-kuzure (mountain-collapse) ‘avalanche’
   c. SU (Vt): kami-kakusi (god-hide) ‘mysterious disappearance’
   d. IO: hito-makase+ (person-depend on) ‘being dependent’
   e. Goal: tera-mairi (temple-visit) ‘temple-going’
   f. Source: ie-de (house-leave) ‘running away from home’
   g. Instrument: suna-asobi+ (sand-play) ‘playing with sand’
   h. Time: yo-asobi+ (night-play) ‘go out and have fun at night’
   i. Adverb: waka-zini+ (young-die) ‘early death’
   j. ‘like a N’: kaeru-tobi (frog-jump) ‘jump like a frog’

F. Nominal predicate (-da ‘be X’)
   a. DO: oya-nakase (parent-cause to cry) ‘being a bad child’
   b. Goal: gaikoku-yuki+ (foreign land-go) ‘foreign bound’
   c. Source: huransu-gaeri (France-return) ‘returnee from France’
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d. Time: Meiji-umare$^+$ (Meiji era-born)‘Meiji generation’
e. Place: Osaka-sodati (Osaka-grow up)‘have grown up in Osaka’

The compounds in (18-E) are all VNs that can be nouns on their own, or verbs to indicate various acts by taking -suru verb or events with -ni naru ‘become’ and -ga aru ‘there is ~’. Considering the fact that these are formally non-distinct from each other, it is not surprising that some of them can be ambiguous depending on the context of use. For example, kutu-migaki ‘shoe polish’ can be Agent ‘shoe polisher’, Instrument ‘shoe polish’ or Act ‘shoe polishing’ (Sugioka 1986: 80)

The composite status of S-J binoms is generally not as transparent as that of the Y or Hybrid compounds. They are either right-headed or left-headed, and are typically composed of one verbal and one nominal/adverbial element. Some examples from Kageyama (1982:231-234) appear in (19).

(19) Types of S-J binoms (N.B. SU: subject, DO: direct object)

a. Intransitive SU: syuk-ka ‘the breaking out of a fire’, tei-den ‘power failure’
b. DO: aku-syu ‘shaking hands’, sen-gan ‘washing one’s face’
c. Goal: ki-koku ‘returning to one’s country’, ryuu-situ ‘entering a room’
d. Location: zai-taku ‘staying home’, tai-kyoo ‘staying in Tokyo’
e. Source: datu-goku ‘escaping from jail’, tai-sya ‘leaving one’s office’
f. Instrument: doku-satu ‘killing with poison’, yuu-soo ‘send by mail’
g. Cause, Reason: sui-si ‘die by drowning’, sen-si ‘die in battle’
h. Various manners: sai-kon ‘re-marry’, ren-syoo ‘win consecutive victories’,
The words in (19-a) – (19-e) have the first verbal elements followed by nominal or adverbial elements, and are left-headed; those in (19-f) – (19-h) have the opposite pattern, and show the regular righthand head percolation. Some of the first members in the latter group, such as *kan-* ('completely'), *zen-* ('entirely') and *sai-* ('again'), might be better understood as prefixes rather than nouns, and they are highly productive.

Vance (1996:26), by quoting Varden (1994), points out that "typical Japanese children have already acquired many Sino-Japanese binoms before they learn to read, but their vocabularies are unlikely to provide much basis for further analyzing these words. In many cases, of course, the relationship between the meaning of a Sino-Japanese binom and the meanings of its constituent morphemes is opaque even to an educated adult."
Chapter Three

INTEGRATED TAXONOMY

3.1. Introduction

Various researchers have acknowledged a number of conditioning factors that seem to be implicated in rdk. This section provides more detailed synchronic (and some relevant historical) descriptions of what is observed in the data with minimum theoretical bias.

All the known factors (and abbreviations in single quotes with ‘+’ indicating a morpheme boundary) are summarized in (20).

(20) Summary of Rendaku Conditioning Factors
(N.B. ‘+Rdk’: rdk-inducing, rdk likely; ‘−Rdk’: rdk-inhibiting, rdk unlikely)

A) Morpheme Class Conditions:

a) Yamato (‘Y’) (+Rdk):
Rdk occurs most frequently in the Y (native) vocabulary.

b) Mimetic (‘M’) and Foreign (‘F’) (−Rdk):
Rdk does not occur in M and F vocabulary.
Chapter 3 — Integrated Taxonomy

e.g.  *haki-haki* (M) ‘briskly’, *supootu-taiya* (F) ‘sports tires’

B) Phonological Conditions:

a) *Lyman’s Law* (*LL*) (*-Rdk*):
   Rdk does not occur when the 2nd element contains a voiced obstruent.
   e.g. *yaki-soba* ‘fried noodles’, *ko-hituzi* ‘lamb’

b) *Nasal or Long Vowel in the first element* (*\( '/n/+^\)\), \( '/LV/+^\)\) (*+Rdk*):
   Rdk is likely when the 1st element ends with \(/n/\) or long vowel.
   e.g.  *nin-zya* ‘professional spy’, *hoo-gaku* ‘a direction’

c) *Voiced Obstruent in the first element* (*\( '/VOb^+/Ob^\)\) (*-Rdk*):
   1) Rdk is unlikely in 3-moraic surnames with 2nd element -*ta* when the 1st element ends with a mora containing a voiced obstruent, e.g., *Siba-ta*  
      *(VOb+ta)*
   2) Rdk is unlikely when it could create two adjacent morae containing identical voiced obstruents across morpheme boundary, e.g., *tobi-hi* ‘sparks’  
      *(tobi-bi)* *(VOb+Ob)*

d) *Mora Structure of Sino-Japanese first element* (*\( '+syo\)\):
   Limited to S-J \([X+syo\) or \( san]\) and \([Y+Z]+syo\) compounds (X, Y, Z denote a single S-J morpheme), rdk is likely when –
   1) X is 1 mora, ending in \(/n/\), e.g., *sin-zyo* ‘bedroom’,
   2) Z is 2 mora, not containing a voiced obstruent, e.g., *[tee.ruua]-zyo* ‘bus stop’,

e) *Double Voiceless Fricatives or /h/+ nasal in the second element* (*\( '+[-VF]^2\)\), \( '+/h/m/\)\) (*-Rdk*):
   Rdk is unlikely when certain types of Y word appear as a 2nd element.
   1) a word beginning with two identical syllables containing a voiceless fricative (*\( '+[-VF]^2\)\)
      e.g. *kare-susuki* ‘withered miscanthus’, *haha* ‘mother’, *susu* ‘soot’, etc.
   2) a word beginning with \(/h/\) immediately followed by a syllable containing a nasal (*\( +/h/m/\)\)
      e.g. *kutu-himo* ‘shoe laces’, *uta-hime* ‘diva’.

f) *Accented short noun compounds* (*\( ‘ACC’\)\) (*-Rdk*):
   Limited to certain short noun compounds, rdk is unlikely when a compound is ‘accented’ (*\( ‘\)\).
   e.g.  *nezumi-tori* (*LHLLL*) ‘mouse trap’, *Ku’bo-ta* (*HLL*) (surname).
C) Syntactic and Morphemic Conditions:

a) **Right Branch Condition** (‘RBC’):
(Compounds with more than two elements) rdk can occur only if the affected compound element is on a right branch at the lowest level in the constituent structure.

  e.g.,  *nuri-[hasi-bako]* ‘chopstick box which is lacquered’
  cf.  *[nuri-basi]-bako* ‘box for lacquered chopsticks’

b) **Prefixes** (‘PX’) (−Rdk):
Rdk is unlikely in prefixed compounds typically with Y ‘honorific’ prefixes, S-J prefixes meaning ‘not’, and in a few numeral prefixes.

  e.g.  *o-hanasi* ‘a talk (hon)’  *bu-kiyoo* ‘awkwardness’,  *hito-koe* ‘one cry’

c) **Coordinate Compounds** (‘CC’) (−Rdk):
Rdk does not occur in coordinate compounds, i.e. when the two elements have equal status.

  e.g.  *yomi-kaki* ‘reading and writing’
  *yama-kawa* ‘mountains and rivers’ (cf. *yama-gawa* ‘mountain river’)

d) **(Non-mimetic) Reduplicated ‘Yamato’ Compounds** (‘RDPY’) (+Rdk):
Rdk occurs in non-mimetic reduplicated Y compounds (‘X added to X’)

  e.g.  *hito-bito* ‘people’ (hito ‘man’),  *toki-doki* ‘sometimes’ (toki ‘time’)

e) **[Verb-stem + Verb] Compound Verbs** (‘[V-s+V]’) (−Rdk):
Rdk is unlikely when a compound verb is a combination of verb-stem + verb.

  e.g.  *osi-toosu* ‘push through’,  *ake-hanatu* ‘throw open’

f) **[Noun (direct object) + Verb-stem (predicate)] Compounds** (‘[D-O+P]’) (−Rdk):
Rdk is more unlikely when the noun 1st element of a compound is grammatically the ‘direct object (argument)’ of the ‘predicate’ verb 2nd element than when it is not (i.e. ‘adjunct-predicate’).

  e.g.  *yane-huki* ‘covering a roof’
  (*yane* ‘roof’ + o (do marker) + *huku* ‘to cover’ = *yane o huku* ‘to cover a roof’)

Thus, rdk is unlikely when a compound noun indicates a name of creature, instrument, game, work or occupation involving the direct object.

  e.g.  *kama-kiri* ‘mantis’,  *mizu-sasi* ‘pitcher’,  *karuta-tori* ‘card game’,
  *genkoo-kaki* ‘manuscript writer’
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D) Semantic Conditions:

*Yamato noun second elements:*

(Limited to Y compounds with -ko, -hi and -sasi) rdk occurs when
1) the 2nd element -ko means ‘a baby or child’, in contrast with ‘a girl, woman’, e.g., sute-go ‘abandoned child’ (vs. odori-ko ‘girl dancer’),
2) the 2nd element -hi means ‘a day’, opposed to ‘the sun’, e.g., getuyoo-bi ‘Monday’ (vs. asa-hi ‘the morning sun’),
3) the 2nd element -sasi means ‘to pierce/prick, skewer’ opposed to ‘sliced raw fish’, e.g., kusi-zasi ‘skewer’ (vs. ika-sasi ‘sliced raw squid’).

E) Other Conditions:

a) *Familiarity* (+Rdk):
   Rdk is more likely when a compound is a commonly used word:
   e.g. koo-zuru ‘to give a lecture’ (cf. koo-suru ‘to navigate’)

b) *Dialectal Variations:* Certain words show dialectal rdk variations.

c) *Historical Change:* Historically, the tendency is from –Rdk to +Rdk.

3.2. Morpheme Class Conditions

3.2.1. ‘Yamato’ (native) morpheme class (+Rdk)

It is often stated rather carelessly that rdk occurs only in Y morpheme class. Although rdk occurs predominantly in the Y class, it is by no means restricted to it. Some S-J words do show rdk, while some Y words do not (Vance 1987, 1996). Martin (1952:48) claims with caution that “(Sequential voicing) is frequent only with Y morph groups”.

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According to the study by Vance (1996:29), rdk affects a much higher percentage of the native samples (87% of 100 items) than the S-J samples (10%). Sato (1989:253) reports that 95% of 2,000 S-J samples do not show rdk, and points out that there are about 80 S-J words that typically undergo rdk. Examples of such S-J second elements include satoo ‘sugar’, kaisya ‘company’, kasi ‘sweets’ and keeko ‘training’. It is commonly regarded that these words are so well-integrated into Japanese that they exceptionally undergo rdk.

3.2.2. ‘Mimetic’ (‘M’) and ‘Foreign’ (‘F’) morpheme classes (–Rdk)

Japanese has a rich store of ideophones or ‘Mimetic Adverbs’ to express repeated or continuous states, sounds and actions. Rdk does not occur in these words (Martin 1952:49). In contrast, according to Martin, reduplication of native ‘non-mimetic’ morphemes (see 3.4.4.) usually involves rdk. Vance (1987:122) points out that the exact repetition of the morpheme is ‘iconic’, since a part of the meaning of such words is repetition or continuation. Thus, the reason why such words do not show rdk is perhaps to preserve their iconicity.

It is fair to say that F words do not show rdk. There are four well-known exceptions, and they are loan words well integrated into Japanese. They are kappa (16c. Portuguese capa: ama ‘rain’ + kappa ‘coat’ → ama-gappa ‘raincoat’), and kiseru (Cambodian khsier: kuwae ‘holding in the mouth’ + kiseru ‘pipe’ → kuwae-giseru ‘pipe in mouth’), and ketto (English (blan)ket) in aka-getto (‘red blanket’) (Nakagawa 1966; Vance 1987). However, these words seem to be very rarely used by young speakers.
3.3. Phonological Conditions

3.3.1. Lyman’s Law (‘LL’) (−Rdk)

Rdk is blocked when the second member of a compound contains a ‘voiced obstruent’.

This is known as Lyman’s Law (‘LL’). Examples are shown in (21).

\[
\begin{align*}
\text{kami} + \text{kaze} & \rightarrow \text{kami-kaze} \quad \text{‘divine wind’} \quad \ast \text{kami-gaze} \\
\text{yaki} + \text{soba} & \rightarrow \text{yaki-soba} \quad \text{‘fried noodles’} \quad \ast \text{yaki-zoba} \\
\text{baka} + \text{sawagi} & \rightarrow \text{baka-sawagi} \quad \text{‘uproar’}
\end{align*}
\]

Note that rdk is blocked regardless of the location of a voiced obstruent. LL has least exceptions, and this is the most powerful and influential factor that blocks rdk. Kindaichi (1976) finds only a few rare exceptions to LL including \text{hun-zibaru} (‘tie up’: cf. an unproductive emphatic prefix \text{hun-} + \text{zibaru} ‘tie’). Vance (1987:137) lists nine counter examples with the second element \text{hasigo} (‘ladder’) as in \text{nawa-basigo} (‘rope ladder’) (cf. \text{nawa} ‘rope’). Vance suspects that the word \text{hasigo} itself is etymologically a compound, and always shows rdk when it appears as the second element in a compound. Some linguists (Sakurai 1966; Maeda 1977; Okumura 1980) therefore claim only that a voiced obstruent in the second mora makes rdk unlikely. Kindaichi’s \text{hun-zibaru} (‘tie up’) does not seem to be the only exception to LL. The researcher’s own dictionary
search\(^2\) gives two additional examples: *hun-zoberu* (‘lie on one’s back’; cf. *soberu* ‘lie on one’s back’) and *hun-zigaru* (‘stand in position’; cf. ‘to pose’) among ten compounds with *hun-* prefix, all of which undergo rdk without exception\(^3\). These two examples seem to qualify as an exception to LL. However, the researcher had never heard of them before, and a few native speakers he consulted expressed the same opinion.

### 3.3.2. Nasal (‘/n/+’) or Long Vowel (‘LV+’) in the first element (+Rdk)

It is known that rdk in Chinese borrowings was once a regular phenomenon after the syllable-final nasals /m/, /n/ or /ŋ/ in original Chinese loans until the 16\(^{th}\) century (Okumura 1980:961-2). Rdk was still a fairly regular practice long after the original Chinese nasals have developed into modern Japanese long vowels (/i/ and /u/) and the mora nasal /n/ (Miller 1967:204-6). Thus, there was once a distinction that a segment following the nasalized vowels derived from original Chinese final /ŋ/ underwent rdk regularly, for example, after the verb *suru* ‘to do’ in *syoo-zuru* ‘yield’, while one following other vowels, such as *hyoo-suru* (‘manifest’) did not (Martin 1952:49-52).

However, subsequent borrowings of different Chinese pronunciations followed by the introduction of newly created S-J words in the 19\(^{th}\) century have weakened and complicated the once regular phenomenon after the long vowels and /n/. In modern Japanese, there remains a small area of vocabulary that seems to retain this phenomenon.


\(^3\) These include *hun-dakuru* (‘snatch roughly’), *hun-zoru* (‘draw oneself up’), *hun-zukamaeru* (‘grab roughly’).
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The examples of this kind appear to be limited to basic two-morpheme S-J words. Examples include nin-zya (‘ninzya’), hon-goku (‘home country’), an-zan (‘mental arithmetic’), syoo-zuru (‘to produce’).

Reflecting this old pattern, in one small proportion of modern two-morpheme S-J words, rdk is likely when the first element ends with /N/. The examples of this kind are limited to the ones with second elements like -koku ‘country’ and -san ‘calculation’ as in hon-goku ‘home country’ (but gai-koku ‘foreign country’), an-zan ‘mental arithmetic’ (but ka-san ‘addition’).

3.3.3. Voiced Obstruent in the first element (‘VOb+Ob’) (~Rdk)

In Old Japanese, rdk also did not take place if either the first or the second member contains a voiced obstruent. This is known as the ‘strong version of LL’. This law had become defunct long ago, but a small proportion of compounds in modern Japanese still seem to reflect this tendency. Examples, cited by several researchers (e.g. Sugito 1965; Nakagawa 1966; Kindaichi 1976; Sato 1983), appear in (22). Note that the same second elements undergo rdk in other compounds.

(22)  a. siba + ta → Siba-ta (family name) *Siba-da
    cf. sima + ta → Sima-da (family name)
  b. tobi + hi → tobi-hi ‘flying sparks’ *tobi-bi
    cf. taki + hi → taki-bi ‘bonfire’
  c. kidu + tukeru → kidu-tukeru ‘give a wound to’ *kidu-duceru
    cf. na + tukeru → na-duceru ‘give a name to’

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This tendency is most strongly observed in three-mora surnames with \(-ta\) as in example (22-a) (Sugitö 1965), and in compounds like (22-b, c) in which \(rdk\) could create two adjacent morae containing identical voiced obstruents. However, this tendency does not hold for longer common surnames: \(Naga-buti, Yanagi-da\), nor for a few words like \(tabi-bito\) (‘traveler’), \(tobi-bako\) (‘vaulting horse’), \(kado-de\) (‘departure’) and \(kizi-zake\) (‘salted pheasant meat with sake’).

3.3.4. Mora structure of Sino-Japanese first element (‘+syö’)

In modern Japanese each S-J morpheme is represented by a single Chinese character or \(kanji\). For example, a S-J word 連関 ‘rendaku’ consists of two kanji; the first member 連 \(ren\) is a monosyllabic, two-mora \((re\) and \(n)\) S-J morpheme. When a S-J word contains a morpheme -syö (‘place, site’) and a few other S-J morphemes, such as -san (‘mountain’) as its right-most constituent, e.g. [X+syö] and [[Y+Z]+syö], the occurrence of \(rdk\) seems to be determined by the structure of the member that precedes -syö. This is illustrated in (23) from Sato (1989:256). X, Y and Z denote a single S-J morpheme.

(23) \(rdk\) and Mora structure of S-J first member + syö (‘place’)

a. \([X+syö], [Y+[X+syö]]\): \(-rdk\) except when a morpheme X ends in /\(N/\)
   e.g. \(yaku + syö \rightarrow yaku-syö\) ‘office’
   \(ka + syö \rightarrow ka-syö\) ‘point, part’
   \(sin + syö \rightarrow sin-zyö\) ‘bedroom’
   \(si + yaku-syö \rightarrow si-yaku-syö\) ‘city hall’

b. \([[Y+Z]+syö\): +\(rdk\) when \(Z\) is 2 mora and does not contain a voiced obstruent.
   e.g. \(tee-ryuu + syö \rightarrow tee-ryuu-zyö\) ‘(bus) stop’ (N.B. ryu.u)
ken-mon + syo → ken-mon-syo ‘checkpoint’ (N.B. mo.n)

cf. tyuu-zai + syo → tyuu-zai-syo ‘police box’ (N.B. za.i)

sai-ban + syo → sai-ban-syo ‘the court’ (N.B. ba.n)

rdk when Z is 1 mora.

e.g. kai-gi + syo → kai-gi-syo ‘conference hall’ (N.B. gi)
too-ki + syo → too-ki-syo ‘registry office’ (N.B. ki)

3.3.5. Double Voiceless Fricatives (‘+[–VF]²’) or /h/ + Nasal (‘+/h//m/’) in the second element (–Rdk)

Rdk does not affect a fraction of words beginning with two identical morae containing a voiceless fricative (e.g. haha ‘mother’, hihi ‘baboon’, hoho ‘cheek’, susu ‘soot’, susuki ‘Japanese pampas grass’) or with /h/ + nasal (e.g. hime ‘princess’, himo ‘rope’) (Kindaichi 1976). Yet, some other words of the same structure (e.g. sasa ‘bamboo grass’, sisi ‘lion’, hone ‘bone’, hane ‘feather’, hune ‘ship’) do have rdk forms. It has been suggested that there was once a variation between the forms himo and hibo (/m/~/b/) in Old Japanese (Nakagawa 1966:311-2, Miller 1967:199); himo (< hibo) could be one of few examples that has persistently resisted rdk (due to LL) up to now.

3.3.6. ‘Accented’ short nominal compounds (‘ACC’) (+Rdk)

It has been pointed out that pitch accent assignment and rdk seem to be related in short noun compounds (Sugitō 1965; Kindaichi 1976; Sato 1989). Rdk is less likely when a compound is short, with the second element being two morae or less, and ‘accented’, i.e.
when there is a pitch fall within a compound (e.g. LHH-LL) as in (24-a), than 'unaccented', i.e. no pitch fall within a compound (e.g. LH-HH) as in (24-b). The apostrophe (') indicates the accent, i.e. the location of pitch fall.

(24) a. yama'-kawa (LHLL) ‘mountains and rivers’
   na’ri-ta (HLL) (place name/family name)
   nezumi’-tori (LHLLL) ‘mouse trap’

b. yama-gawa (LHHH) ‘mountain river’
   te-dori (LHH) ‘net profit’
   ume-bosi (LHHH) ‘pickled Japanese apricot’

This tendency, however, is not consistent in longer compounds. The compounds like those in (25) do show rdk although they are accented.

(25)  kana-du’kai (LHLLL) ‘use of Kana’
      yasai-du’kuri (LHHLLL) ‘growing vegetables’

3.4. Syntactic and Morphemic Conditions

3.4.1. Right Branch Condition (‘RBC’)

It has been briefly explained earlier that in compounds with more than two elements, the internal constituent structure of the compound determines whether rdk can apply or not.

There is a condition, traditionally known as ‘Right Branch Condition’ (Ôtsu 1980),
('RBC') which predicts rdk application in such compounds. It says that when a compound consists of three or more elements, rdk applies only when the affected morpheme is on a right branch constituent at the lowest level of compound structure. The pair given in (26) illustrates schematically the internal branching structures of the compounds we have seen earlier in Chapter One.

(26)

\[
\begin{align*}
\text{a.} & \quad \text{take-basi-bako} \\
& \quad \text{take-basi} \\
& \quad \text{take-hasi-bako} \\
& \quad \text{take} \\
& \quad \text{hako} \\
\text{b.} & \quad \text{take-hasi-bako} \\
& \quad \text{hasi-bako} \\
& \quad \text{take} \\
& \quad \text{hasi} \\
& \quad \text{hako}
\end{align*}
\]

‘a box for bamboo chopsticks’  ‘a chopstick box made of bamboo’

Here, the absence of rdk in (26-b) \textit{take-hasi-bako}, opposed to \textit{take-basi-bako} in (26-a), is accounted for by the RBC; since only the member on a right branch at the lowest level undergoes rdk, \textit{hasi} in (26-b), which is on the left branch, does not undergo rdk. Previously in (9), this blocking of rdk is attributed to LL; i.e. the voiced obstruent in the right-most member: \textit{hasi-bako} blocks a further application of rdk in the further compounding, and the result is \textit{take-hasi-bako}. However, as we will see in (27) below, there is a rare but problematic case where this account appears inadequate.
The meaning of the compound 'lacquered umbrella' suggests that first, *kasa* and *ire* are combined to give *kasa-ire* ('umbrella case'). Rdk is apparently not applicable here. Next, *nuri* and *kasa-ire* are combined, and rdk is expected in this second compounding since LL does not prevent rdk in *kasa-ire*. Nevertheless, rdk does not take place, and the result is *nuri-kasa-ire*. RBC explains that this is because *kasa-ire* is on a right branching constituent, but is not at the lowest level. RBC successfully accounts for problematic cases like in (27) as well as the instances like in (26). Rdk is therefore subject to RBC in longer compounds as long as LL is not violated (for the Optimality Theoretic analysis of RBC by Itô and Mester 1998; see 4.3.5.).

3.4.2. Prefixes (‘PX+’) (–Rdk)

Rdk never occurs after the honorific prefixes *o-* and *go-* as in *o-hanasi* (‘talk-HON’) and *go-kuroo* (‘hardship-HON’). Rdk usually does not occur after the S-J prefixes *hu-* and *bu-* (‘not’) (Nakagawa 1966:309-310). Thus, *bu-kiyoo* (‘awkwardness’), but *ko-giyoo* (‘cleverness’). It is also known that rdk never occurs after certain types of Y numeral
prefixes like hito- (‘one’) (e.g. hito-koto ‘one word’), and mi- (‘three’) (e.g. mi-toori ‘three ways’) but often occurs after others (e.g. huta-go ‘twins’) for some reason. Note that the common native suffixes o- and ko- (‘small’), and oo- (‘big’), on the other hand, do not block rdk, e.g. o-gawa (‘brook’), ko-bune (‘small boat’), oo-goe (‘loud voice’).

Nakagawa (1966:309-310) claims that the native Japanese numeral prefixes inhibit rdk although there are exceptions after huta- in huta-go (‘twins’) (cf. ko ‘child’). This is certainly true for hito- and mi-, but not for other numeral prefixes like yotu- (‘four’), mutu- (‘six’), yatu- (‘eight’) and so on. The prefix mi- also has an alternative form mitu-, and it does not inhibit rdk.

3.4.3. Coordinate compounds (‘CC’) (–Rdk)

So-called coordinate (or dvandva) compounds (2.5.) shown in (28) below, in which two elements have the same status or the relation of coordination, do not show rdk. Note that each of the second elements does undergo rdk in non-coordinate compounds.

(28)  
  a. tosi + tuki → tosi-tuki ‘years and months’  
  cf. mika + tuki → mika-duki ‘crescent’
  
  b. uri + kai → uri-kai ‘selling and buying’  
  cf. syoodoo + kai → syoodoo-gai ‘impulse buying’
  
  c. siro + kuro → siro-kuro ‘white and black’  
  cf. iro + kuro → iro-guro ‘dark colored’

Nakagawa (1966) and Maeda (1977) cite an example which the same two elements are involved in both a coordinate and a non-coordinate compound: yama-kawa (yama
mountain’ + kawa ‘river’ = ‘mountains and rivers’) and yama-gawa meaning ‘mountain river’. The absence of rdk in coordinate (exocentric) compounds leads us to speculate that rdk has a function of indicating the modifier-head relationship between the two elements in the compound.

3.4.4. (Non-mimetic) Reduplicated Yamato compounds (‘RDPY’) (+Rdk)

We have seen that rdk does not occur in M words including reduplicated ones. In contrast, rdk always occurs in ‘non-mimetic’ reduplicated compounds in Y. Examples include hito-bito (‘people’; hito ‘man’), kata-gata (‘everyone’; kata ‘person-HON’), toki-doki (‘sometimes’; toki ‘time’). As Vance (1987:141) speculates, compounds of this kind may indicate a meaning of [X on top of X] or [X added to X] as in hito-bito (= hito ‘person’ added to hito). Martin (1952:65) says that these morphemes indicate ‘universality, variety and plurality’.

3.4.5. [Verb-stem + Verb] compound verbs (‘[V-s+V]’) (−Rdk)

Rdk is far less frequent when a compound is a ‘verb’ of [V-stem+V] type. Here, the first element V-s (verb-stem) corresponds to what Sugiokea (1986) refers to as VN (deverbal nominal), mentioned earlier in 2.6.1. and 2.6.4.. Lyman (1894) notes this tendency, and Nishio and Miyajima (1971) (in Sugiokea 1986:110), find only eleven rdk compounds out of 667 potential cases (compared to 142/154 of [N(oun) + V] type); Vance
(1987:143-4) reports a similar figure. As we will see, this appears to be related to the lack of clear semantic headedness in many of such compounds. The compound verbs can be classified into three types in terms of the semantic relationship that holds between the two verb members: ‘X and Y’ (represented as [X-Y]), ‘X modifies Y’ (as [X/m-Y]), and ‘X is modified by Y’ (as [X-Y/m]). This is exemplified in (29) below.

(29) a. [X-Y] naki + sakebu → naki-sakebu ‘cry-shout’ = ‘to cry and shout’
    b. [X/m-Y] sasi + korosu → sasi-korosu ‘stab-kill’ = ‘to stab to death (kill by stabbing)’
    c. [X-Y/m] uri + tukusu → uri-tukusu ‘sell-exhaust’ = ‘to sell off’

The comparatively rare [X-Y] type in (29-a) has the meaning of conjunction: ‘do X-ing and Y-ing’ where the two verbs have the same status. The [X/m-Y] type in (29-b) could be paraphrased as sasi-te korosu (stab-CONJ + kill) (‘kill by stabbing’). The X/m describes the manner in which the action denoted by the Y is carried out; thus, the Y alone has the predicate function. In contrast, (29-c) cannot be paraphrased as *ut-te tukusu (sell-CONJ exhaust), but rather to mean ‘to sell everything in stock’. The Y/m in this type functions more like a suffix to the predicate X, adding various aspectual or metaphorical meanings rather than its original meanings (i.e. we can say ‘he sells’ but not ‘he exhausts’). However, determining the semantic head of these compounds is not always easy. For example, kaeri-zaku (kaeru ‘return’ + saku ‘bloom’) means ‘to bloom a second time, to make a comeback’, but its semantic type, i.e. [X/m-Y] or [X-Y/m], depends on whether the subject is a flower or a person. This kind of ambiguity is probably the major factor that discourages rdk in such structures.

A conventional and rather intuitive account is that rdk is unlikely when the two...
verbs are loosely compounded to imply the coordination of two different and independent actions or states in sequence, rather than more tightly compounded verbs indicating relatively synchronized or simultaneous actions or states. Observe the following examples from Sato (1989:257-8).

(30)

a. \( \text{iki} + \text{tumaru} \rightarrow \text{iki-dumaru} \) 'go-be blocked' = 'to reach an impasse'

\( \text{ike} + \text{toru} \rightarrow \text{ike-doru} \) 'keep alive-capture' = 'to capture alive'

\( \text{ne} + \text{kaeru} \rightarrow \text{ne-gaeru} \) 'sleep-turn over' = 'to betray, double-cross'

\( \text{tati} + \text{tomaru} \rightarrow \text{tati-domaru} \) 'stand-stop' = 'stop walking, halt'

b. \( \text{osi} + \text{toosu} \rightarrow \text{osi-toosu} \) 'push-let through' = 'go through by pushing, persist to the end'

\( \text{ake} + \text{hanasu} \rightarrow \text{ake-hanasu} \) 'open-release' = 'to keep wide open'

Compared to those in (30-b), in which the independent actions follow the others (note that \( \text{ake-hanasu} \) means 'open wide and leave it' rather than 'release by opening'), those in (30-a) are probably more rigid in that the first verbs explain the state or environment in which the second actions take place. However, considering the fact that all the examples here appear to be of \([X/m-Y]\) type, and there are many other -rdk cases in which the same second elements are involved in equally opaque semantic types like (30-a), it is questionable whether this is an adequate account of the situation.

3.4.6. [Noun (direct-object) + Verb-stem (predicate)] compounds ('[D-O+P]') (−Rdk)

In short nominal compounds of \([N+V-s]\) type (i.e. \([N+VN]\) type), rdk is more unlikely
when the noun first member is grammatically the direct object (D-O) of the verb, the predicate (P), than when it is not. A pair in (31) illustrates this contrast.

(31) a. \textit{yane} + \textit{huki} $\rightarrow$ \textit{yane-huki} ‘covering a roof’
    ‘roof’ ‘covering’
    cf. \textit{yane (d-o) o huku} \textit{(verb)} ‘to cover a roof’ \textit{(o: direct-object marker)}

b. \textit{kawara} + \textit{huki} $\rightarrow$ \textit{kawara-buki} ‘tiled roof’
    ‘tile’ ‘covering’
    cf. \textit{kawara de (yane o) huku} \textit{(verb)} ‘to cover (a roof) with tile’ \textit{(de: instrumental marker)}

While D-O and the VN in (31-a) stand in argument-predicate relationship and they together name an action, the N and VN in (31-b) stand in modification relationship (i.e. adjunct-predicate; see 2.6.4.) by which a certain kind of act is restricted to its subkind. This generalization, although it holds for a fair number of compounds of this type, has some exceptions. In (32) below rdk occurs in one and not in the other even though the nouns function as a D-O. Certain verb-stems like \textit{kari} (‘hunting’), \textit{kiri} (‘cutting’), \textit{kaki} (‘writing’), \textit{kai} (‘buying’) all behave in this way.

(32) a. \textit{ni} + \textit{tukuri} $\rightarrow$ \textit{ni-dukuri} ‘packing (pack one’s luggage)’
    ‘luggage’ ‘making’
    cf. \textit{niwa} + \textit{tukuri} $\rightarrow$ \textit{niwa-tukuri} ‘gardening (making one’s garden),’
    ‘garden’ ‘making’

b. \textit{hude} + \textit{tukai} $\rightarrow$ \textit{hude-dukai} ‘handling a writing brush’
    ‘brush’ ‘using’
    cf. \textit{hebi} + \textit{tukai} $\rightarrow$ \textit{hebi-tukai} ‘snake charmer (using snakes)’
    ‘snake’ ‘using’
Chapter 3 — Integrated Taxonomy

What matters here seems to be the semantic distinctions among compounds of this type. Essentially, rdk is very unlikely when a short compound noun stands in [D-O+P] relationship to indicate a person whose ‘occupation’ involves the D-O. This seems to explain well the absence of rdk in certain names of creatures, instruments and games. Examples of this kind are shown in (33).

(33)

a. \( \text{ari} + \text{kui} \rightarrow \text{ari-kui} \) ‘anteater’
   ‘ant’ ‘eating’
   \( \text{yado} + \text{kari} \rightarrow \text{yado-kari} \) ‘hermit crab’
   ‘house’ ‘renting’

b. \( \text{midu} + \text{sasi} \rightarrow \text{midu-sasi} \) ‘water pitcher’
   ‘water’ ‘pitching’
   \( \text{tume} + \text{kiri} \rightarrow \text{tume-kiri} \) ‘nail clippers’
   ‘nails’ ‘cutting’

c. \( \text{karuta} + \text{tori} \rightarrow \text{karuta-tori} \) ‘card game’
   ‘cards’ ‘taking’
   \( \text{yubi} + \text{kiri} \rightarrow \text{yubi-kiri} \) ‘making a promise with little fingers linked’
   ‘fingers’ ‘cutting’

3.5. Semantic Conditions: Yamato Noun Second Elements

There are a fair number of examples that should show rdk but still fail to do so. Nakagawa (1966:311-314) lists a number of semantic conditions that affect the occurrence of rdk in [noun + verb] compound nouns: 1) creature (species) names do not show rdk, e.g., \( \text{kama-kiri} \) (‘mantis’), \( \text{ari-kui} \) (‘anteater’), etc. 2) Instrument names do not show rdk, e.g., \( \text{hon-tate} \) (‘bookstand’), \( \text{tume-kiri} \) (‘nail clippers’). 3) Names of work,
occupations or games do not show rdk, e.g., *genkoo-kaki* ('manuscript writer'), *karuta-tori* ('karta/card game'). 4) Names of objects/products (resulting from the action upon the D-O) show rdk, e.g., *garasu-bari* ('glazing'), *ume-bosi* ('pickled Japanese apricot'). 5) Rigid compounds regarded as one word (thus, one action or object/product) show rdk, e.g., *asi-bumi* ('stamping'), *me-bari* ('sealant, sealing').

Similarly, there are some morphemes that consistently undergo rdk, but others that consistently resist. These include *tuti* ('soil'), *himo* ('string'), *kemuri* ('smoke'), *saki* ('tip'), *sio* ('tide'). One homophone of *saki* ('tip'; V-stem), namely *saki* ('bloom'; V-stem) always shows rdk. The other homophone *saki* ('promontory'), on the other hand, often shows rdk. It has been suggested that some morphemes like *saki* ('tip') have been resisting rdk to retain a semantic distinction.

Certain common Y morphemes have both +rdk and −rdk forms to indicate a semantic distinction. For example, distinction is made for *hi* between meaning 'the rays, sunlight, day' with rdk: *nisi-bi* ('afternoon sunlight'), *getuyoo-bi* ('Monday'), and 'the sun' without rdk: *asa-hi* ('the morning sun'), *hatu-hi* ('the first sunrise of the year'). However, a few others (e.g. *ki* 'tree' *kusa* 'grass') behave inconsistently in that a semantic distinction between +rdk and −rdk forms is not as apparent as *ki* (e.g. *niwa-ki* 'garden tree', and *yama-gi* 'mountain tree'). Family names are particularly bewildering in this respect, since they are highly lexicalized compounds. Names with both forms like *Ta-zima* vs. *Ta-sima* (surname) are not uncommon.
3.6. Other Conditions

3.6.1. Familiarity

It is well known that familiarity of compounds (or members) is another important factor (e.g. Okumura 1972; Akinaga 1966, 1977). Essentially, rdk is less common in less familiar words. Some words, like *ki-kaeru* (‘to change clothes’), seem to have gained rdk due to more familiar versions, like the deverbal noun *ki-gae* (‘spare clothes for changing’).

3.6.2. Dialectal variations

It is reported that dialectal differences are observed in some cases. It is known that *sen-taku* (‘washing’) is commoner in Eastern Japan than *sen-daku* in the West except the area of Cyūgoku, west of Sikoku and the island of Kyūsyū (Tokugawa 1977:285).

3.6.3. Historical change

There has been a historical tendency of some –rdk words becoming +rdk partly due to their increased familiarity (e.g. Okumura 1980; Akinaga 1966, 1977). On the other hand, a number of words in Modern Japanese have lost or have been losing rdk due to the widespread awareness among the educated literate of the original pronunciations of
characters involved.

All these cases reflect the complicated situation in modern Japanese. For this reason, most researchers agree that rdk is fundamentally an irregular phenomenon. Among all the factors mentioned so far, the ‘morpheme class restriction’, ‘CC’, ‘RDPY’, ‘LL’ and perhaps ‘PX+’ seem to be the maximally general and consistent conditions that govern rdk. The other factors are limited to the specification of some of the circumstances under which rdk does (or does not) occur.
Chapter Four

RENDAKU IN OPTIMALITY THEORY

4.1 Introduction

In this chapter, we take a very different look at some of the facts about rdk in the light of Optimality Theory (‘OT’: Prince and Smolensky 1993, McCarthy and Prince 1993a, b, 1994, 1995) for two reasons. First of all, among the contemporary theories of generative grammar, OT has produced some remarkable and most up-to-date research results particularly in a variety of prosodic and segmental phenomena including rdk. Secondly, its viewpoint of Universal Grammar (‘UG’) and the lexicon is fundamentally different from that of classical rule-based generative theory although the theory shares with rule-based predecessors the central position taken by UG. Most importantly, rules of grammar are replaced by interactions of universal constraints in grammar. This assumption alone has a significant consequence on predictions about learnability and acquisition of rdk, which has never been considered before.

This chapter is organized as follows. First of all, section 4.2. introduces the current OT analyses of the rdk phenomenon including the motivation behind rdk voicing, LL, stratum-specificity and the right-branch condition (RBC). In section 4.3., the key assumptions and predictions about learnability and acquisition in OT are addressed. This is followed by a demonstration of how learning of OT grammar can be achieved by Recursive Constraint Demotion (‘RCD’) algorithm (Tesar and Smolensky 1996, 1998,
2000). Then, a step-by-step learning simulation of rdk grammar is presented as a basis for a prototype acquisition model of rdk. Section 4.4. considers the possibility of abnormal immature rdk grammars and their opaque outputs that could result during the course of acquisition under certain scenarios. Finally, section 4.4.5. summarizes hypothetical rdk acquisition models and their expected/unexpected ungrammatical outputs.

4.2. Preliminaries

Probably the most successful accounts of rdk have been offered within the constraint-based approach of OT. As we will see, the OT account has now proven superior to that from traditional ‘rule-and-derivation’ theories (‘RDT’) in that it has achieved a higher level of explanation. OT differs fundamentally from the basic notions of RDT in several important respects. Critically, there are no rules, and thus no rule ordering relationships, no derivations, no intermediate levels of representation, and no language-specific restrictions on the set of underlying representations. Instead, for any given input (or commonly known as underlying form ‘UR’), a ranked set of universal constraints evaluates in parallel a potentially infinite set of candidates and selects one as optimal, i.e. the most ‘harmonic’. The optimal candidate is the one that best satisfies the constraint hierarchy. Constraints (Con), ideally included in UG, are of at least two fundamental and often antagonistic types, namely ‘markedness’ constraints and ‘faithfulness’ constraints. Markedness constraints evaluate the well-formedness of output candidates, favouring certain structural configurations over others. Faithfulness constraints, on the other hand, demand identity between input and output strings. Unlike other theories in which constraints are inviolable, OT constraints are violable, and to be understood as specific empirical hypotheses about UG that OT posits. The basic components of OT are: a lexicon which can provide input candidate sets, a ranked set of violable constraints, and an evaluation function which eliminates non-optimal
candidates. The core components of OT are summarized in (35).

(35) Core Components of the OT grammar

LEXICON: contains lexical representations (or underlying forms) of morphemes (roots, stems, and affixes) of a language, including phonological, morphological, syntactic, and semantic properties, which form the input to:

GENERATOR: generates output candidates for some input, and submits these to:

EVALUATOR: the set of ranked constraints, which evaluates output candidates as to their harmonic values, and selects the optimal candidate (phonological surface form, syntactic S-Structure, etc.).

Then, the basic two-layered OT architecture is as shown in (36) below.

(36) Basic OT architecture

\[ \text{input} \rightarrow \text{GEN} \rightarrow \text{candidates} \rightarrow \text{EVAL} \rightarrow \text{output} \]

A universal and automatic GEN receives an input and generates a set of candidates. Another universal function EVAL applies the language-particular constraint hierarchy \( \mathcal{H} \) to this candidate set, locating its most harmonic member: the output. Among the core components, the OT conception of the input is one of the significant points of diversion from earlier derivational theories. In pre-OT phonology (and syntax), different forms of limitations/restrictions, such as lexical/phonological redundancy rules, morpheme structure constraints, or the lexicon itself, are often imposed on input to account for between-language variation such as inventory restrictions. OT, however, assumes that no language-particular restrictions hold at the level of input; the set of possible inputs to the grammar is universal and innate. This is one of the most fundamental principles of the theory. In other words, inputs in any language are free to contain any kind of linguistic primitives (e.g. phonological or morpho-syntactic features) in free combination. This principle (37) is known as \textit{Richness of the base} (‘ROTB’), first
proposed in Prince and Smolensky (1993):

(37) Richness of the base:

The source of all systematic cross-linguistic variation is constraint reranking. In particular, the set of possible inputs to the grammars of all languages is the same. The grammatical inventories of languages are defined as the forms appearing in the outputs that emerge from the grammar when it is fed the universal set of all possible inputs.

(Prince and Smolensky 1993:191)

This means that the grammar and the lexicon are no longer integrated via devices like redundancy rules, morpheme structure constraints or underspecification. All languages share the same set of potential inputs (= base). All differences in the inventory of elements permitted in surface structure must be derived from the interactions of markedness and faithfulness constraints. ROTB is a natural consequence of one of the central and perhaps striking assumptions in OT — a single invariant ranking of constraints represents the grammar of each language.

In OT grammar, the learnability burden is reduced to the learning of the constraint ranking and the establishment of lexical representations. Constraint ranking is all that the language learner must discover in order to arrive at the target grammar. The issue of learning constraint hierarchies — learnability of OT grammar — has been acknowledged and elaborated since the first arrival of the theory itself. One of the current views holds that learning is essentially achieved by an algorithm which deduces relevant rankings from cross-comparisons of constraint violations (rather than satisfaction) between the attested output, namely positive evidence, and other candidates. Positive evidence consists of the grammatical forms — optimal outputs of the grammar — available in the child’s linguistic environment. Yet negative evidence consists of the ungrammatical forms — suboptimal outputs of the grammar — normally not available in the primary data. Among various algorithm models is the RCD algorithm developed by Tesar and
Chapter 4 — Rendaku in Optimality Theory

Smolensky (1996)⁴. Ranking and re-ranking always involve constraint demotion, and the demotion must be 'minimal' in that a constraint is demoted to a position immediately below the highest-ranking constraint that induces its violation in the optimal output.

The process of acquisition is presumed to proceed by the re-ranking of constraints, specifically by the minimal demotion of markedness constraints (Tesar and Smolensky 1996, 1998, 2000). Another important prediction is that the initial state of the algorithm is [Markedness \textit{\textgreater} Faithfulness]: default ranking of markedness constraints over the antagonistic faithfulness constraints (e.g. Gnanadesikan 1995; Smolensky 1996a, b; Tesar and Smolensky 2000, among others). Various acquisition data suggest that many production errors that occur in early stages of development have only been characterized by the ranking; yet some researchers argue otherwise, namely [F \textit{\textgreater} M] (Hale and Reiss 1998).

4.3. Rendaku, Lyman’s Law and Correspondence Theory

4.3.1. Morpheme-based floating feature analysis

OT assumes that whenever some phonological alternation occurs in a language, some markedness constraint is satisfied at the expense of violating a faithfulness constraint. In other words, the language in question gives priority to markedness over faithfulness; thus there is a ranking “markedness \textit{\textgreater}” (‘dominates’ or ‘is higher-ranked than’) faithfulness”. Such faithfulness constraints are collectively known as IDENTITY-IO(F) which require the F(eature) value of an input segment be identical in its output. When one or more IDENT[F] constraints are dominated by some markedness constraint, this

⁴ There are other alternative models to the constraint demotion algorithm such as the Gradual Constraint-Ranking Learning algorithm (Boersma and Levelt 2000), and the expanding parsing algorithm (Hale and Reiss 1997, 1998).
leads to featural disparity and phonological alternation.

Based on this OT assumption, Itô and Mester (1998:25-28) posits a linking [voice] morpheme and the faithfulness constraint \texttt{SEQVOI} that give rise to rdk voicing. Following Itô and Mester (1986), Itô and Mester (1998) suggest that rdk voicing can be regarded as a junctural morpheme ‘$p$’ (i.e., a linking ‘prefix’ bearing the feature [voice] underlingly, positioned in the input representation as a ‘place-holder’) attached as a prefix to the second member of the compound. This is schematically shown in (38).

(38) \[ \text{word} \]
\[ \text{stem}_1 \quad \text{stem}_2 \]
\[ \text{ori} \quad \text{p} + \text{kami} \]
\[ \text{‘paper’} \quad \text{‘folding’} \]

Rdk voicing occurs when the [voice] feature of the prefix $p$ (denoted by $[\text{voice}]_p$) is realized at the surface as a part of the initial obstruent of the second member. As Itô and Mester (1999:28) note, \texttt{SEQVOI} can be encoded as a phenomenon-specific linking morpheme $[\text{voice}]_p$ and an universal faithfulness constraint called \texttt{REALIZE-MORPHHEME} which forces the feature to surface in the output which is violated when a certain morpheme has no output realization. For the current purpose, Itô and Mester’s \texttt{SEQVOI} is used as a provisional reference to the ‘input morpheme + \texttt{REALIZE-MORPHHEME}’ constraint until noted otherwise.

One markedness constraint plays a key role in OT analysis of rdk (as well as German and Dutch syllable-final devoicing, for example). It is named \texttt{VOICED OBSTRUENT PROHIBITION (‘VOP’)} after Itô and Mester (1998:11) given in (39).

(39) \text{Voiced Obstruent Prohibition (VOP): *[+voi, –son]} \]
\[ \text{(An obstruent must be voiceless)} \]

---

5 For an alternative analysis, see also Itô and Mester (1998:55-60).
It is a segmental markedness constraint banning voicing of obstruents, while placing no restriction on the voicing of sonorants. Since voicing is distinctive in Japanese obstruents, VOP must be dominated by the faithfulness constraint IDENT[voice] as in (40) – otherwise Japanese would have no voiced obstruents at all.

\[(40) \quad \text{IDENT[voice]} \rightarrow \text{VOP} : \text{obstruents may be voiced or voiceless}\]

(IDENT[voice]: the specification for the feature [voice] of an input segment must be preserved in its output correspondent)

In order for rdk voicing to manifest correctly, IDENT[voice] must be dominated by SEQVOI to ensure that the morpheme p is parsed at the surface. We have the basic ranking (41).

\[(41) \quad \text{SEQVOI} \rightarrow \text{IDENT[voice]} \rightarrow \text{VOP}\]

This ranking correctly chooses the winner (42-a) below that is more faithful to SEQVOI than IDENT[voice], as illustrated in the form of a tableau in (42)

\[(42)\]

<table>
<thead>
<tr>
<th>/ori + p + kami/ ‘folding paper’</th>
<th>SEQVOI</th>
<th>IDENT[voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ori + gami]</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. [ori + kami]</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Listed vertically in the left-most column are the input and two output candidates. The candidates are listed in random order. Horizontally in the top row are the constraints, in a descending ranking from left to right: from the higher-ranked SEQVOI to the lower VOP. The cells contain violation marks ‘*’ incurred by each candidate for the constraint heading the column. Candidate (42-b) violates SEQVOI due to the floating [voice] feature that results from the morpheme φ not being realized. This is a fatal violation, that is, a violation of the highest-ranked constraint in the set, marked by the exclamation mark ‘!’. Although candidate (42-a) violates each of the lower-ranked constraints, (42-b) is decisively ruled out by SEQVOI. The shading of cells means that the violation content is no longer relevant for the decision. The optimal candidate, marked by the index ‘*’, is [ori-gami] since no candidate is available that fares better.

The junctural morpheme analysis equates rdk to essentially a morphological process. Given the ranking of constraints, it allows the voicing to surface. The next section looks at the case where the rdk voicing does not surface. It will be shown that the blocking effect of LL is motivated by the locally-conjoined markedness constraint that interacts with the basic ranking obtained so far.

### 4.3.2. Lyman’s Law, OCP and Local Constraint Conjunction

As we have seen, rdk is blocked when the second element of a compound contains a voiced obstruent (43).

\[(43)\]

\[
\text{word} \quad \text{stem}_1 \quad \text{stem}_2
\]

\[
*:\text{SEQVOI} \quad \text{[+voi,−son]}
\]
This is what traditionally referred to as LL (see 3.3.1.). More recently, this blocking
effect has been seen as the operation of the *Obligatory Contour Principle* (‘OCP’)
effect on [voice] feature in the native Yamato class of Japanese. In phonology, the OCP
prohibits adjacent identical elements except across morpheme boundaries (McCarthy
1986). It is not a constraint on double occurrences of the feature [+voice], but rather on
adjacent occurrences of the feature combination [+voice, –son]. This OCP effect holds
throughout the native Y morpheme class, exemplified by the sample pairs in (44).

(44) a. *futa  ‘lid’
b. *fuda  ‘sign’
c. buta  ‘pig’
d. *buda  (non-existent)

As a result, what is traditionally known as LL can be restated as (45) a part of the
constraint which disallows more than one voiced obstruent within a Y stem in a
compound.

(45) Lyman’s Law: “Stems must not contain more than one voiced obstruent”

Itô and Mester (1996) and Alderete (1997) independently propose that the OCP is a
self-conjunction of markedness constraints in some local domains (46).

(46) Dissimilation as Local Conjunction (Alderete 1997:2):

OCP effects are derived by markedness constraints, doubled in a local context.

Itô and Mester conclude that a constraint specifically for OCP is redundant because the
full set of the self-conjoined markedness constraints can account for all OCP
phenomena (see McCarthy 1986 for the taxonomy of OCP-effects). The idea of
self-conjunction has been developed as an extension of *Local Constraint Conjunction*
('LCC'), originally proposed by Smolensky (1993, 1995). Self-conjunction (47) obtains when two identical markedness constraints $C_i$ and $C_j$ are conjoined ('self-conjoined') in a certain local domain $\delta$ (e.g. within a morpheme, syllable, phonological phrase, etc.) to play the role of 'double' constraint, written $[C_i \& C_j]_\delta$, that prohibits the co-occurrence of $C_i$ with itself in the same domain (Smolensky 1995 in Itô and Mester 1998:17).

\[(47)\] Self-conjunction of constraints: $[C_i \& C_j]_\delta$, with $C_i = C_j$

Evaluation of $[C_i \& C_j]_\delta$: $[C_i \& C_j]_\delta$ is violated in domain $\delta$ if there is more than one violation of $C_i$ in domain $\delta$. (Smolensky 1995 in Itô and Mester 1998:17)

The OCP-type dissimilation effects, such as LL, typically arise by the ranking in (48).

\[(48)\] Dissimilation as Local Conjunction of $A$: $[*A \& *A]_\delta \gg F \gg *A$

In domain $\delta$, such as a morpheme, a faithfulness constraint $F$ (typically of the IDENT-variety with the relevant feature specification) intervenes in the ranking between a lower-ranked markedness constraint $*A$ (which prohibits the marked element $A$) and the higher-ranked self-conjoined constraint $[*A \& *A]_\delta$ that prohibits the sequence of $AA$ in the same domain (or bans double violations $*A*A$), while single violation $*A$ is tolerated. Under the new conception of OCP-dissimilation, Alderete (1997) and Itô and Mester (1998) propose that the OCP effect on the [voice] feature, namely VOP, can be reduced to a locally enhanced self-conjunction of the markedness constraint $[VOP \& VOP]$ or $\text{VOP}^2_\delta$, given in (49).

\[(49)\] $\text{VOP}^2_\delta$ "No co-occurrence of voiced obstruency with itself for the domain $\delta$" (no double obstruent voicing in domain $\delta$)  

(cf. OCP $[+\text{voi},-\text{son}]: *[+\text{voi},-\text{son}] [+\text{voi},-\text{son}]$)
The conjoined constraint VOP^s must be linked to a local domain δ. For the analysis of rdk and LL in compounds, it must be specified as a ‘stem’. Compare the following examples, both Y compounds, in (50).

(50) a. /yaki/ + /soba/ → [yaki-soba] *[yaki-zoba]
   ‘fried’ ‘noodles’ ‘fried noodles’

   b. /tabi/ + /hito/ → [tabi-bito]
   ‘travel’ ‘person’ ‘traveler’

In (50-a) rdk is blocked by the presence of the voiced obstruent (i.e. the [voice] feature) in the second element soba, that is within a single stem. In (50-b), on the contrary, the OCP effect is not observed and rdk takes place even though the word contains two [voice] features seemingly adjacent to each other, but not in the same stem. Tableau (51) illustrates the latter case.

(51) OCP not observed across stem boundary: /tabi/ + /hito/ → [tabi-bito]

<table>
<thead>
<tr>
<th>/tabi + p + hito/ ‘traveler’</th>
<th>VOP^s</th>
<th>SEQVOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>[v] [v]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| [tabi + hito] | | *!
| [v] [v]p | | |
| [tabi + bito] | | Not violated
| [v] [v]p | | |

In order to explain the asymmetry, the domain δ of the conjoined constraint VOP^s must be specified as a stem; i.e. VOP^stem (the issue of such domain specification will be taken up later in 4.3.3. and 4.3.4.).

Now, LL is redefined as a constraint against double occurrences of the feature combination [+voi,−son] within a Y stem. As a consequence, LL in Japanese can be captured by the following ranking (cf. Itô and Mester 1998:24):
(52) LL in Japanese Y stems (in compounds):

\[ \text{VOP}^2_{\text{Stem}} \gg \text{IDENT}[\text{voice}] \gg \text{VOP} \]

From (52) and the ranking given earlier in (41), the constraint ranking hierarchy (53) can be constructed for the Japanese case (cf. Alderete 1997:5; Itô and Mester 1998:27) from which the OCP-effect on obstruent [+voice], namely the blocking of SEQVOI by LL results.

(53) Constraint Ranking of Rdk and LL:

\[ \text{VOP}^2_{\text{Stem}} \gg \text{SEQVOI} \gg \text{IDENT}[\text{voice}] \gg \text{VOP} \]

The ranking (53) states that LL – avoiding two or more voiced obstruents within a stem – is more important than obeying compound voicing of rdk. The following tableau (54) illustrates how rdk is blocked via LL.

(54) Rdk blocked by LL:

<table>
<thead>
<tr>
<th>/yaki + p + soba/ ‘fried noodle’</th>
<th>VOP$^2_{\text{Stem}}$</th>
<th>SEQVOI</th>
<th>IDENT[voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [yaki + zoba]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [yaki + soba]</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This ranking (53), however, requires further analysis. In tableau (55) below, there could be another candidate (55-c) [yaki + zopa], which is in fact more faithful to both VOP$^2_{\text{Stem}}$ and SEQVOI than the winner (b) [yaki + soba] in (54). This wrong winner is shown in (55).
Problematic case with the ranking (53):

\[
VOP^2_{\text{stem}} \gg \text{SEQVOI} \gg \text{IDENT}[\text{voice}] \gg VOP
\]

<table>
<thead>
<tr>
<th>/yaki + p + soba/</th>
<th>VOP^2_{\text{stem}}</th>
<th>SEQVOI</th>
<th>IDENT[voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;desired output&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [yaki + soba]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[v][v]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;wrong winner&gt;</td>
<td></td>
<td></td>
<td>**</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>c. [yaki + zopa]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[v][v]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In order to eliminate cases like this, the ranking can be refined by further specifying two kinds of faithfulness constraints for [voice]: \text{IDENT}[+\text{voice}] and \text{IDENT}[-\text{voice}]\(^6\). This is exemplified in (56) – (58) below. First, as exemplified in tableau (56) below, \(VOP^2_{\text{stem}}\) must dominate faithfulness to [+voice]:

\[
VOP^2_{\text{stem}} \gg \text{IDENT}[+\text{voice}]
\]

<table>
<thead>
<tr>
<th>/buda/ (hypothetical)</th>
<th>VOP^2_{\text{stem}}</th>
<th>IDENT[+voice]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [buda]</td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td>b. [buta]</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Next, \text{IDENT}[+\text{voice}] must outrank SEQVOI to ensure that underlyingly [+voice] obstruents are not ‘devoiced’ to obey the OCP.

\(^6\) [+F] and [-F] versions of IDENT is proposed by Pater (1995). As we will see later in 4.3.3.2., these constraints could be replaced by correspondence constraints for features, i.e. \text{MAX}[F]/\text{DEP}[F] pair. For example, \text{IDENT}[+\text{voice}] by \text{MAX}[\text{voice}] (“no [voice] deletion”) and \text{IDENT}[-\text{voice}] by \text{DEP}[\text{voice}] (“no
Chapter 4 – Rendaku in Optimality Theory

(57) \text{IDENT}[+\text{voice}] \gg \text{SEQVOI}

<table>
<thead>
<tr>
<th>/yaki + p + soba/</th>
<th>\text{VOP}_{\text{Stem}}</th>
<th>\text{IDENT}[+\text{voice}]</th>
<th>\text{SEQVOI}</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [yaki + zoba]</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [yaki + soba]</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [yaki + zopa]</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. [yaki + sop]</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At the same time, faithfulness to [−voice] must be dominated by \text{SEQVOI} (58) so that the rendaku candidate (58-b) wins against (58-a) that is faithful to [−voice].

(58) \text{SEQVOI} \gg \text{IDENT}[−\text{voice}]

<table>
<thead>
<tr>
<th>/hasi + p + hako/</th>
<th>\text{SEQVOI}</th>
<th>\text{IDENT}[−\text{voice}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [hasi + hako]</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [hasi + bako]</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

The interaction of rendaku and LL is summarized in the overall ranking given in (59).

(59) \text{VOP}_{\text{Stem}} \gg \text{IDENT}[+\text{voice}] \gg \text{SEQVOI} \gg \begin{cases} \text{VOP} \\ \text{IDENT}[−\text{voice}] \end{cases}

To summarize all the possible rendaku cases considered so far under the ranking (59), we have the following tableaux listed in (60-1) – (60-4).
Chapter 4 – Rendaku in Optimality Theory

(60)  Rdk and LL under the ranking (59)

(1) Sonorant in the 2nd element: /ori + p + kami/ → [ori-gami]

<table>
<thead>
<tr>
<th>/ori + p + kami/</th>
<th>VOP₂&lt;sup&gt;stem&lt;/sup&gt;</th>
<th>IDENT [+voice]</th>
<th>SEQVOI</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ori + kami]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>¬¬ b. [ori + gami]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) Voiceless obstruent in the 2nd element: /hasi + p + hako/ → [hasi-bako]

<table>
<thead>
<tr>
<th>/hasi + p + hako/</th>
<th>VOP₂&lt;sup&gt;stem&lt;/sup&gt;</th>
<th>IDENT [+voice]</th>
<th>SEQVOI</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [hasi + hako]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>¬¬ b. [hasi + bako]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [hasi + hago]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) Voiced obstruent in the 1st element: /tabi + p + hito/ → [tabi-bito]

<table>
<thead>
<tr>
<th>/tabi + p + hito/</th>
<th>VOP₂&lt;sup&gt;stem&lt;/sup&gt;</th>
<th>IDENT [+voice]</th>
<th>SEQVOI</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [tabi + hito]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>¬¬ b. [tabi + bito]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>c. [tapi + hito]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(4) Voiced obstruent in the 2nd element (LL): /yaki + p + soba/ → [yaki-soba]

<table>
<thead>
<tr>
<th>/yaki + p + soba/</th>
<th>VOP₂&lt;sup&gt;stem&lt;/sup&gt;</th>
<th>IDENT [+voice]</th>
<th>SEQVOI</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [yaki + zoba]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>¬¬ b. [yaki + soba]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [yaki + zopa]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. [yaki + sopa]</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to (60-1) to (60-4) above, we need to consider another rdk case (60-5) in
which the second member of the compound already contains an initially voiced obstruent as in a Y compound *hana-gara* (/hana/ ‘flower’ + /gara/ ‘pattern’). There are two phonetically identical candidates (60-5-b) and (60-5-c).

(60-5) Voiced initial obstruent in the 2nd element: /hana + p + gara/ \[→ [hana-gara]

<table>
<thead>
<tr>
<th>/hana + p + gara/ [v] [v]</th>
<th>VOP^2 Stem</th>
<th>IDENT [[{voice}]]</th>
<th>SEQ VOI</th>
<th>IDENT [[-voice]]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [hana + kara]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [hana + gara] [[v][v]]</td>
<td></td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [hana + gara] [[v][v]]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

While rdk is simply blocked (the \[voice\]p is not linked) in candidate (60-5-b), candidate (60-5-c) undergoes first, the devoicing of \[gara\] (the \[voice\] feature delinked) and then voicing \[kara\] again via rdk (the \[voice\]p re-linked) to yield \[gara\], a phonetically identical output as (b). Although the current ranking chooses (c) as a winner, this result is undesirable because candidate (b) is more faithful to the ‘association line’ configuration in the input than (c). The problem is that the constraint ranking is blind to such a configuration. It only sees the input-output identity of the \[voice\] feature. This case will be taken up later under new analysis in (70) in 4.3.4.4.

In the following sections, the ranking (59) will be further analyzed and elaborated under the concept of *Correspondence Theory*. 
4.3.3 Domain, Correspondence Theory and relativized faithfulness

4.3.3.1 Eliminating local domain from OCP

We now return to the domain issue mentioned in the previous section. Despite its theoretical strength, several aspects of LCC (as well as self-conjunction) require further formulation. One of them is the unrestricted and arbitrary specification of a phonologically local domain of OCP/self-conjunction. It is argued that the selection of the domain is determined in a rather stipulative, ad-hoc manner. In the present case, VOP is only operative within a stem. Moreover, recall that the stem must belong to the Y vocabulary. Consequently, there is no choice but to stipulate that the domain for the OCP/self-conjunction for each phenomenon in the language must be learned; the child has to take the burden of learning the domain which is apparently language-specific as well as process/phenomenon-specific. By questioning the 'universality' of such domain specification, particularly with respect to its repercussions in the process of language acquisition, Fukazawa (1999) and Fukazawa and Kitahara (2001) propose an alternative 'relativised faithfulness' analysis with respect to distinct lexical strata in Japanese in an attempt to eliminate the domain stipulation. This idea of multiple faithfulness has emerged from various developments in Correspondence Theory. Previous studies have shown that the interaction of the faithfulness constraints from different sets accounts for some domain-specific alternation phenomena observed within a language (McCarthy and Prince 1994; Beckman 1995; Lombardi 1995a). Continuing research by Urbanczyk (1996a, b), Benua (1995, 1997), Fukazawa, Kitahara and Ota (1998), Itô and Mester (1999), among others, have contributed to the advancement of the idea of correspondence from specific local domain to larger morphological units and categories such as lexical strata within a language.
4.3.3.2. Correspondence Theory and relativised faithfulness

The concept of relativised faithfulness is motivated by the theoretical development of Correspondence Theory, first proposed by McCarthy and Prince (1995). Correspondence relations are obtained between identity of representations such as segments, features and prosodic/structural units, but all types of such linguistic relations are generalized as follows.

(61) **Correspondence:**
Given two strings $S_1$ and $S_2$, **correspondence** is a relation $\mathcal{R}$ from the elements of $S_1$ to those of $S_2$. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as **correspondents** of one another when $\alpha \mathcal{R} \beta$.

Unlike markedness constraints, faithfulness constraints are organized in sets (or families) of correspondence constraints, such as $\text{MAX(imality)}$, $\text{DEP(endence)}$, $\text{IDENT(ity)}$, $\text{CONTIGUITY}$, $\text{LINEARITY}$, $\text{UNIFORMITY}$, $\text{ANCHOR}$, $\text{ALIGN}$, depending on types of representations under investigation (e.g. McCarthy and Prince 1995; Lombardi 1995a, b; Lamontagne and Rice 1995; McCarthy 1995; Itô, Mester and Padgett 1995; Causley 1997).

In addition, although faithfulness in OT was originally an input-output correspondence relation only, Correspondence Theory further develops the approach to faithfulness, and recognizes different types of identity between representations which can hold between any two linguistic relations such as Input-Output (IO), Base-Reduplicant (BR), Output-Output (OO), and so on. Thus, every relation generates a full, comparable set of faithfulness constraints: IO: $\{$MAX-IO, DEP-IO, IDENT-IO, UNIFORMITY-IO, $\ldots$$\}$; BR: $\{$MAX-BR, DEP-BR, IDENT-BR, $\ldots$$\}$; OO: $\{$MAX-OO, DEP-OO, $\ldots$$\}$, etc. The following are the list of correspondent constraints on elements and their definitions (McCarthy and Prince 1995, 1999); each constraint actually comes in a constraint-family, with instantiations for I-O, B-R, I-R, and so on. All relate strings $S_1$ (input, base, etc.) to $S_2$ (output, reduplicant, etc.).
Correspondence Constraints:

a. The **Max(imality)** Constraint Family
   Every segment of \( S_1 \) has a correspondent in \( S_2 \).
   \( \text{Domain}(9l) = S_1 \)
   
   E.g. **Max-IO**: Every segment of the input has a correspondent in the output. (No phonological deletion.)
   
   **Max-BR**: Every segment of the base has a correspondent in the reduplicant. (Reduplication is total)

b. The **Dep(endence)** Constraint Family
   Every segment of \( S_2 \) has a correspondent in \( S_1 \). (\( S_2 \) is “dependent on” \( S_1 \).)
   \( \text{Range}(9l) = S_2 \)

c. The **Ident(ity)** Constraint Family
   Let \( a \) be a segment in \( S_1 \) and \( \hat{\beta} \) be any correspondent of \( a \) in \( S_2 \).
   If \( a \) is \([yF]\), then \( \hat{\beta} \) is \([yF]\).
   (Correspondent segments have identical values for the feature \( F \).)

d. The **Contiguity** Constraint Family
   d-1. **I-Contig** (“No Skipping”)
      The portion of \( S_1 \) standing in correspondence forms a contiguous string.
      \( \text{Domain}(9l) \) is a single contiguous string in \( S_1 \).
   d-2. **I-Contig** (“No Intrusion”)
      The portion of \( S_2 \) standing in correspondence forms a contiguous string.
      \( \text{Range}(9l) \) is a single contiguous string in \( S_2 \).

e. The **Anchor** Constraint Family
   **Right-Left**-Anchor \((S_1, S_2)\)
   Any element at the designated periphery of \( S_1 \) has a correspondent at the designated periphery of \( S_2 \).
   Let \( \text{Edge}(X, \{L, R\}) = \) the element standing at the \( \text{Edge} = L, R \) of \( X \).
   
   **Right-Anchor**. If \( x = \text{Edge}(S_1, R) \) and \( y = \text{Edge}(S_2, R) \) then \( x \preceq y \).
   
   **Left-Anchor**. Likewise, \textit{mutas mutandis}.

f. The **Linearity** Constraint Family – “No Metathesis”
   \( S_1 \) is consistent with the precedence structure of \( S_2 \), and vice versa.
   Let \( x, y \in S_1 \) and \( x', y' \in S_2 \).
   
   If \( x \preceq x' \) and \( y \preceq y' \), then \( x < y \) if \( y' < x' \).
g. The **Uniformity** Constraint Family – “No Coalescence”

No element of $S_2$ has multiple correspondents in $S_1$.
For $x, y \in S_1$ and $z \in S_2$, if $x \not\approx z$ and $y \not\approx z$, then $x = y$.

h. The **Integrity** Constraint Family – “No Breaking”

No element of $S_1$ has multiple correspondents in $S_2$.
For $x \in S_1$ and $w, z \in S_2$, if $x \not\approx w$ and $x \not\approx z$, then $w = z$.

(McCarthy and Prince 1995:16-8, 122-4; 1999:293-6)

According to the theory, a full set of faithfulness constraints exists for each type of faithfulness relation. Several sets of them can coexist in one single grammar, and are ranked in relation to each other or the markedness constraints depending on the grammar concerned. This gives rise to various alternations in languages as repair strategies: degemination, dissimilation, assimilation, epenthesis, and metathesis, as pointed out by Yip (1988), to avoid OCP violations. Following Yip’s categorization of OCP effects on segments, Fukazawa (1999) claims that some of these phonological processes cannot repair the OCP on features, and therefore need to be modified accordingly. She suggests there are four types of languages regarding the OCP on features (63).

(63) **Typology of the OCP effects on features** (Fukazawa 1999:27):

(a) Type 1 language: OCP violation is observed.

(b) Type 2 language: OCP violation is not allowed, and Featural Fusion takes place. (Dissimilation & Assimilation).

(c) Type 3 language: OCP violation is not allowed, and Feature Deletion and Feature Insertion both occur. (Dissimilation)

(d) Type 4 language: OCP violation is not allowed, and Feature Deletion leads to Segmental Deletion. (Deletion)

Table (64) summarizes all the correspondence constraints for segments proposed by McCarthy and Prince (1995), in which it is assumed that segments alone stand in
correspondence, so identity of features must be evaluated indirectly, only through segments bearing those features via \textsc{ident}[F]. However, as we will see in the next section, this assumption has to be extended to features as well as segments.

(64) Table of Correspondence Constraints for Segments

<table>
<thead>
<tr>
<th>Type of Constraint</th>
<th>What is prohibited:</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>Segmental Deletion</td>
</tr>
<tr>
<td>DEP</td>
<td>Segmental Epenthesis</td>
</tr>
<tr>
<td>\textsc{ident}[F]</td>
<td>Featural Change with respect to the segments</td>
</tr>
<tr>
<td>(I,O)-CONTIGUITY</td>
<td>Segmental Skipping (I-CONTIG)</td>
</tr>
<tr>
<td></td>
<td>Segmental Intrusion (O-CONTIG)</td>
</tr>
<tr>
<td>ANCHOR ALIGNMENT</td>
<td>Segmental Misalignment</td>
</tr>
<tr>
<td>LINEARITY</td>
<td>Segmental Metathesis</td>
</tr>
<tr>
<td>UNIFORMITY</td>
<td>Segmental Coalescence</td>
</tr>
<tr>
<td>INTEGRITY</td>
<td>Segmental Splitting</td>
</tr>
</tbody>
</table>

(Fukazawa 1999: 39)

4.3.3.3. Faithfulness on features

The question is how can Correspondence Theory account for the OCP effect that involves featural identity? Note that the only constraint on features in (64) above is \textsc{ident}[F]. Attempts have been made to extend \textsc{ident} to operate over classes of features. Lombardi (1995a) and Lamontagne and Rice (1995) propose that both MAX[F] and DEP[F] are necessary to account for deletion and insertion of features. Thus, \textsc{ident}[F] would be replaced by the MAX[F]/DEP[F] pair, with additional constraints to ensure faithfulness of features to their original segmental associations. Causley (1997) argues that features must be treated as ‘independent elements’ of segments so that the full independent set of faithfulness constraints (e.g. MAX[F], DEP[F], UNIFORMITY[F]) should be introduced. Causley’s UNIFORMITY[F], for example, constrains featural fusion. Some other researchers (e.g. McCarthy 1995) have also shown that in order to explain
the effect of OCP on features successfully, features need to be treated as independent ‘entities’. Based on these claims, Fukazawa (1999) gives the full range of featural faithfulness constraints whose interaction is crucial to the analysis of the OCP on features (65).

(65) Constraints for the Typology of OCP effects on Features

(a) \( \text{OCP}[\text{F}] = [*\text{FF}_{\text{DOMAIN}}] \)

(b) \( \text{MAX}[\text{F}] \): Every feature of the input has a correspondent in the output (no featural deletion) (Lombardi 1995a, Lamontagne and Rice 1995)

(c) \( \text{DEP}[\text{F}] \): Every feature of the output has a correspondent in the input (no featural insertion) (Lombardi 1995a, Lamontagne and Rice 1995)

(d) \( \text{UNIFORMITY}[\text{F}] \): No feature of the output has multiple correspondents in the input (no featural fusion) (McCarthy and Prince 1995, Causley 1997)

(e) \( \text{MAX}-\text{IO} \): Every segment of the input has a correspondent in the output (no segmental deletion) (McCarthy and Prince 1995)

(Fukazawa 1999:51)

4.3.4. The domain/stratum-specificity problem

4.3.4.1. Five lexical strata in Japanese

It has been mentioned earlier that rdk and LL are not maximally general phenomena in Japanese. Stems belonging to M(imitic) and F(oreign) classes, henceforth referred to as ‘stratum’ or ‘sub-lexica’, are not susceptible to rdk nor LL. For the present explanatory purposes, it is also assumed that those from S-J stratum do not show rdk either (despite the fact that handful of them do). Such phenomena pose a serious problem to the fundamental principle of OT: the grammar of each language consists of one single invariant constraint ranking. The current single ranking does not always yield a correct result. For example, consider the S-J case in (66) in which the ranking chooses the
wrong winner (66-a).

(66) A wrong result for a sub-lexicon: ‘S-J’ /kan/ + /tai/ → [kan + tai] ‘warm reception’

<table>
<thead>
<tr>
<th>/kan + tai/ ‘warm reception’</th>
<th>VOP\textsuperscript{2, \text{Sem}}</th>
<th>IDENT [+voice]</th>
<th>SEQ\text{Voi}</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;wrong winner&gt;</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>a. [kan + dai]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;desired output&gt;</td>
<td></td>
<td></td>
<td>*\dagger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [kan + tai]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEQ\text{Voi} penalizes candidate (66-b), and the winner is the rdk candidate (66-a), which is not a desired output. The ranking incorrectly predicts that rdk does occur in the S-J words. How can we account for a language with more than one lexical stratum without distorting the fundamental principle of OT?

4.3.4.2. Multiple IO-faithfulness on features

As mentioned earlier, the concept of relativised faithfulness has been advanced by Urbanczyk (1996a, b) and Benua (1995, 1997). They suggest that the faithfulness constraints can be relativized to account not only for the general/specific domain, but also for distinct morphological units and categories within a language. It follows that each morphological class may display a unique correspondence relation. For example, Benua (1995, 1997) concludes that in English, there are two kinds of Output-Output (OO) faithfulness relations: class 1 affixation (e.g. *condemnation [k\text{\text{\text{-}demne}\text{\text{-}j}an}]*) and class 2 affixation (e.g. condemning [k\text{\text{\text{-}demnin}]}) each gives rise to its own correspondence relation to the output of the root morphemes. It is therefore possible for each of the basic pairs (IO, BR, OO, etc.) to bear multiple full sets of faithfulness constraints for each morphological class within a language.

Building on these studies, Fukazawa (1998, 1999) and Fukazawa, Kitahara and
Ota (1998) claim that the stratum-specificity in Japanese can be handled by stratum-specific IO correspondence relations: IO-Yamato, IO-Sino-Japanese, IO-Mimetic, IO-Assimilated foreign (= Foreign), and IO-Unassimilated foreign (= Alien). A full set of faithfulness constraints can be multiplied for each relation (67), interacting in the same grammar of Japanese.

(67) Split IO-faith for each stratum

- **IO-Y:** \{Max-IO-Y, Dep-IO-Y, Ident[F]-Y, Integ-IO-Y, \ldots\}
- **IO-S-J:** \{Max-IO-S-J, Dep-IO-S-J, Ident[F]-S-J, Integ-IO-S-J, \ldots\}
- **IO-M:** \{Max-IO-M, Dep-IO-M, Ident[F]-M, Integ-IO-M, \ldots\}
- **IO-F:** \{Max-IO-F, Dep-IO-F, Ident[F]-F, Integ-IO-F, \ldots\}
- **IO-A:** \{Max-IO-A, Dep-IO-A, Ident[F]-A, Integ-IO-A, \ldots\}

(Fukazawa 1998:3)

A similar approach is independently proposed by Itô and Mester (1999) that stratally indexed faithfulness constraints are ‘interleaved’ at different points of a single grammar.

The next section introduces the unified account based on the analyses by Fukazawa, Kitahara and Ota (1998) and Fukazawa (1999).

4.3.4.3. The domain problem and relativised faithfulness

In order to eliminate the domain specified to the OCP, Fukazawa and Kitahara (2001) propose that Uniformity[voice]: “no [voice] feature of the output has multiple correspondents in the input (i.e. no fusion of the two [voice] features)” is the relevant constraint to be relativised depending on each phonological domain. The OCP/self-conjunction VOP\(^2\) is no longer specified with the domain ‘stem’; instead, the Uniformity[voice] (“no [voice] fusion”) constraint is split into the ‘general’ Uniformity constraint Uniformity[voice]-G(eneral), and the specific Uniformity
constraint for within a morpheme, \texttt{UNIFORMITY[voice]-M(orpheme)}. This implies, according to Fukazawa and Kitahara (2001:99), that there is a universal possibility of being more faithful in a smaller domain than in a larger (or more general) domain, and that the relativization of \texttt{UNIFORMITY[voice]} could be possible within other distinct domains larger than a morpheme.

Tableau (68) below reexamines (60-3) without domain specification of \texttt{OCP[+voi, -son]}. To be consistent with Fukazawa and Kitahara’s analysis, the following terms are used accordingly: \texttt{OCP[+voice, -sonorant]} = VOP, \texttt{REALIZE-MORPHHEME} = SEQ\textsc{V}O\textsc{i}, and *\texttt{[+voice, -sonorant]} = VOP.

(68) Reanalyzed version of (60-3): /\texttt{tabi/+/hito/} \rightarrow [\texttt{tabi-bito}] without OCP domain.

\texttt{OCP[+voi, -son]}, \texttt{UNIFORMITY[voice]-M} \Rightarrow \texttt{REALIZE-MORPHHEME} \Rightarrow \texttt{UNIFORMITY[voice]-G}

<table>
<thead>
<tr>
<th>/\texttt{tabi} + p + \texttt{hito}/</th>
<th>\texttt{OCP}</th>
<th>\texttt{UNIFORMITY}</th>
<th>\texttt{REALIZE-MORPHHEME}</th>
<th>\texttt{UNIFORMITY}</th>
</tr>
</thead>
<tbody>
<tr>
<td>[v] [v]</td>
<td>\texttt{[+voi, -son]}</td>
<td>\texttt{[voice]-M}</td>
<td></td>
<td>\texttt{[voice]-G}</td>
</tr>
<tr>
<td>a. \texttt{[tabi + hito]}</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. \texttt{[tabi + bito]}</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. \texttt{[tabi + bito]}</td>
<td>\texttt{[v]}</td>
<td>\texttt{[v]_k}</td>
<td>*</td>
<td>\texttt{[voice]-G}</td>
</tr>
<tr>
<td>d. \texttt{[tapi + hito]}</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Under the new analysis, the relativised faithfulness \texttt{UNIFORMITY[voice]-M} is specified to the domain ‘within a morpheme’. In (68), candidate (b), the winner in the previous analysis (60-3), becomes a loser under this new analysis due to the fatal violation of \texttt{OCP[+voi, -son]} that is no longer specified for any phonological domain. Instead, there is another candidate (68-c), phonetically equivalent to (68-b), where featural fusion is...

\footnote{Fukazawa (1999) and Fukazawa and Kitahara (2001) use ‘morpheme’ for the constraint’s domain instead of ‘stem’. This reflects the fact that the OCP-effect holds for any \textsc{Y} morpheme exemplified earlier in (46). Positing \texttt{UNIFORMITY[voice]-M} (instead of ‘stem’) and \texttt{UNIFORMITY[voice]-G} is more accurate in a sense that it differentiates two types of stem: a single stem (e.g. \texttt{hito}) from a complex stem (e.g. \texttt{tabi-bito});}
possible to repair OCP[+voi, -son] violation, (according to the typology shown in (65)), becomes the winner as a result of the ranking in which the general constraint UNIFORMITY[voice]-G is lower-ranked than the morpheme-specific constraint UNIFORMITY[voice]-M and REALIZE-MORPHEME.

4.3.4.4. Correspondence theoretic analysis of LL

Let us turn to the new analysis of LL, previously stated in (45) as “stems must not contain more than one voiced obstruent”. In the new conception of OCP and relativised faithfulness, we have a revised analysis of LL given in (69) below. Note that IDENT[+voice] and IDENT[−voice] are replaced by correspondence constraints MAX[voice] and DEP[voice]. Additional constraints MAX[assoc.] and DEP[assoc.] are also introduced to rule out candidates like (69-f) where ‘re-linking’ and ‘de-linking’ of association lines are possible.

(69) LL in $Y$ – revised version of (60-4): /yaki/+/soba/ → [yaki-soba]

<table>
<thead>
<tr>
<th>/yaki + p + soba/</th>
<th>OCP</th>
<th>UNIFORMITY</th>
<th>MAX</th>
<th>MAX</th>
<th>REALIZE</th>
<th>DEP</th>
<th>DEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>[v] [v]</td>
<td>[+voi, -son]</td>
<td>[voice]-M</td>
<td>[assoc]</td>
<td>[voi]</td>
<td>MORPHEME</td>
<td>[assoc]</td>
<td>[voi]</td>
</tr>
<tr>
<td>a. [yaki + zoba]</td>
<td>![</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>![v] [v]</td>
<td>b. [yaki + soba]</td>
<td>![v] [v]</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
</tr>
<tr>
<td>![v] [v]</td>
<td>c. [yaki + zopa]</td>
<td>![v] [v]</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
</tr>
<tr>
<td>![v] [v]</td>
<td>d. [yaki + sopa]</td>
<td>![v] [v]</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
</tr>
<tr>
<td>![v] [v]</td>
<td>e. [yaki + zoba]</td>
<td>![v] [v]</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
</tr>
<tr>
<td>![v] [v]</td>
<td>f. [yaki + soba]</td>
<td>![v] [v]</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
<td>![</td>
</tr>
</tbody>
</table>

Positing UNIFORMITY[voice]-S(tem) is hence problematic as it treats both the same.
The current ranking correctly chooses the winner (69-b) that simply deletes the association line of the linking morpheme p to obey the higher-ranked constraints OCP[+voi, -son], UNIFORMITY[voice]-M and MAX[voice]. Candidate (69-a) fatally violates OCP[+voi, -son], while candidates (69-c) and (69-d) lose due to violations of MAX[assoc.] and MAX[voice]. It should be noted that here in (69), two more candidates (69-e) and (69-f) could be considered. Candidate (e) – phonetically equivalent to (a) – satisfies OCP by fusing the two [voice] features, but is penalized by UNIFORMITY[voice]-M that disallows featural fusion within the morpheme. As for candidate (f) – phonetically equivalent to the winner (b) – the feature [voice]p is ‘delinked’ from p, and the input [voice] is also delinked from the second member /soba/ where the [voice]p is re-linked. This is catered for by positing a set of faithfulness constraints for association lines MAX[assoc.] and DEP[assoc.]. The double violation of MAX[assoc.] makes it a fatal loser against (b). The problematic case, already given in (60-5) where the second member has an initial voiced obstruent, is catered for in the same way in the revised tableau (70).

---

8 The violation of MAX[assoc.] in (69) is based on the fairly technical definition that rdk results from the delinked [voice]p from p relinked to the initial segment of the second member. In this sense, every candidates violates MAX[assoc.] at least once. Perhaps a more intuitive account is that as long as [voice]p is linked to the initial segment of the second member, as in (69-a, c, e), MAX[assoc.] is satisfied.

9 It could be argued technically, in a strictly morphological sense, that a stem/morpheme like {soba} in (69-e) could be regarded as a 'complex morpheme' with the junctural morpheme (= prefix) [voice], being attached to another morpheme (= stem) {soba}. Itô and Mester (1998:55) explain that this junctural morpheme “consists of the floating feature specification [+voice], and it is realized by the association of this feature specification to the first segment to its right.” It could be understood that UNIFORMITY[voice]-M is violated when two voice features, each of which is linked to one of two [+obst] segments that belong to the same morpheme, are fused into one [voice].
(70) Revised version of (60-5): /hana + gara/ → [hana-gara] ‘flower pattern’

<table>
<thead>
<tr>
<th>/hana + p + gara/</th>
<th>MAX[assoc.]</th>
<th>REALIZE-MORPHME</th>
<th>DEP[assoc.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[v] [v]</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>a. [hana + gara]</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[v], [v]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [hana + kara]</td>
<td>**!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[v], [v]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [hana + gara]</td>
<td>**!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>[v], [v]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Technically, all candidates violate MAX[assoc.] at least once because [voice]p must be delinked from p first to be relinked to the adjacent segment10. The analyses successfully get rid of the domain specification from the conventional OCP account of LL, and attribute it to the interaction of context-free OCP-dissimilation and the relative ranking of the split IO faithfulness constraints UNIFORMITY[voice]-M and UNIFORMITY[voice]-G.

4.3.4.5. Stratum-specificity problem and multiple I-O faithfulness

To complete the overall picture of relevant constraints and their ranking that are responsible for rdk, we need one extra device to restrict operation of these to the Y stratum. Under the current theoretical framework, multiple IO faithfulness constraints can account for the stratum-specific phonological phenomena in Japanese. To account for the stratum-specificity of rdk and LL, Fukazawa (1999) proposes multiple DEP[assoc.]-IO (“no insertion of the association line”) indexed for each of the five strata in Japanese: DEP[assoc.]-Y, DEP[assoc.]-S-J, DEP[assoc.]-M, DEP[assoc.]-F and DEP[assoc.]-A. The ranking DEP[assoc.]-S-J, M, F, A \( \gg \) REALIZE-MORPHME \( \gg \) DEP[assoc.]-Y is proposed to ensure that rdk occurs only in the Y stratum. Tableau (42) in 4.3.1. is revised as (71) below. In order for rdk to manifest itself in the Y stratum,

---

10 For a more straightforward analysis, one can argue that a case like (70-c) should not be treated as a MAX[assoc.] violation because the association line from [voice]p to the initial segment is present.
**REALIZE-MORPHEME** must outrank **DEP[assoc.]-Y**. The faithfulness constraint **DEP[assoc.]-Y** prohibits insertion of the association line (linking the [voice] feature of the prefix morpheme ρ to the initial obstruent of the second member) when the second member of a compound is from the Y morpheme class, while **DEP[assoc.]-S-J, M, F, A** do not when the second member is from the non-Y vocabulary. The given ranking states that in the Y stratum, the absence of rdk (i.e. [ori + kami]) is fatal, while that of **DEP[assoc.]-Y ([ori + gami])** is not.

(71) Rdk in Y stratum – revised version of (42): ‘Y’ /ori + kami/ → [ori-gami]  

**DEP[assoc.]-S-J, M, F, A**  
**REALIZE-MORPHEME**  
**DEP[assoc.]-Y**

<table>
<thead>
<tr>
<th>/ori + ρ + kami/</th>
<th>OCP [+voi, –son]</th>
<th><strong>DEP[assoc.]-S-J, M, F, A</strong></th>
<th><strong>REALIZE-MORPHEME</strong></th>
<th><strong>DEP[assoc.]-Y</strong></th>
<th><em>[+voi, –son]</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ori + gami]</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. [ori + kami]</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

The analysis in (71) is superior to (42) in that the restricted occurrence of rdk in the Y stratum is explained by the relative ranking of the multiple faithfulness constraints **DEP[assoc]**. In turn, the given ranking ensures that rdk does not occur in S-J, M, F and A strata. This also means that whatever compounding occurs in the Y stratum, the optimal candidate (with or without rdk) is correctly chosen as long as **REALIZE-MORPHEME** is simultaneously dominated by OCP[+voice, –son], UNIFORMITY[voice]-M, MAX[assoc.], MAX[voice] and **DEP[assoc.]-S-J, M, F, A**.

4.3.4.6. Rdk in S-J: revisited

Taking up this line of analysis, we can reexamine rdk in the S-J stratum. The previous analysis (66) in 4.3.4.1. yields a wrong result for S-J by choosing the wrong winner
*{kan + dai} with rdk. This is reproduced in (72).

(72) A wrong result for a sub-lexicon (repeated from (66))

<table>
<thead>
<tr>
<th></th>
<th>VOP_{Sam}</th>
<th>IDENT [+voice]</th>
<th>SEQVOI</th>
<th>IDENT [-voice]</th>
<th>VOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;wrong winner&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* a. [kan + dai]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>&lt;desired output&gt;</td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. [kan + tai]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The revised analysis of (72), shown below in (73), correctly predicts that the winner in the S-J stratum is the non-rdk candidate (73-b) [kan + tai]. Candidate (73-a) [kan + dai] loses because it violates the faithfulness constraints Dep[assoc.]-S-J, M, F, A (no insertion of the association line in S-J, M, F, and A morpheme classes). That is, when the second member of a compound comes from the non-Y morpheme class, namely S-J, M, F and A strata, insertion of the association line to the initial obstruent of the second member is prohibited.


<table>
<thead>
<tr>
<th></th>
<th>OCP [+voi, −son]</th>
<th>Dep [assoc./] S-J, M, F, A</th>
<th>REALIZE-MORPHEME</th>
<th>Dep [assoc./] Y</th>
<th>*[+voi, −son]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [kan + dai]</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [kan + tai]</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thus, rdk is not observed in this S-J compound (in which both members are S-J) because Dep[assoc.]-S-J is higher-ranked than Realize-Morpheme.

To illustrate this case further, consider the following S-J example from Fukazawa (1999) in (74) where the second member of a S-J compound contains a voiced obstruent. Again, both members of the compound are S-J.
(74) Rdk blocked in a S-J compound: /koo + taiguu/ → [koo-taiguu]  
'good' 'treatment' 'good treatment'

\[
\begin{array}{|c|c|c|c|c|c|}
\hline
/koo + \rho + taiguu/ & OCP & DEP & Uniformity & Realize-Morpheme & DEP \\
\hline
a. [koo + daiguu] & *! & *! & & & \\
[v], [v] & & & & & \\
b. [koo + daiguu] & & *! & & & \\
\vee_b & & & & & \\
c. [koo + taiguu] & & & * & & \\
[v], [v] & & & & & \\
\hline
\end{array}
\]

(Fukazawa 1999:256)

With the same ranking of the same constraints, the rdk candidates (a) and (b) are ruled out by OCP[+voice, -son] and DEP[assoc.]-S-J, M, F, A, and the optimal candidate is (c). This means that in non-Y strata, rdk does not occur, and so-called LL becomes invisible. We see from (73) and (74) that compounds with non-Y second members are not affected by rdk regardless of whether they contain a voiced obstruent or not, and the optimal candidate always satisfies OCP[voice, -son] and DEP[assoc.]-S-J, M, F, A. This is clear from a rare but real S-J example (75) in which both the first and second S-J members already contain a voiced obstruent.
(75) Rdk blocked in a S-J compound – (2): /bu + syuugi/ → [bu-syuugi]  
‘un-’ ‘fortune’ ‘misfortune’

<table>
<thead>
<tr>
<th>/bu + p + syuugi/</th>
<th>OCP [+voi,-son]</th>
<th>DEP [assoc.-S-J,...]</th>
<th>UNIFORMITY [voice]-M</th>
<th>REALIZE-MORPHEME</th>
<th>UNIFORMITY [voice]-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>[v] [v] [v]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. [bu + syuugi]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[v] [v] [v]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [bu + zyuugi]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[v] [v] [v]</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. [bu + zyuugi]</td>
<td></td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>[v] [v]</td>
<td></td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>d. [bu + zyuugi]</td>
<td></td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

It is shown that rdk and consequently LL are not observed in the S-J stratum because the faithfulness constraint DEP[voice] is stratally-indexed for S-J (vs. non S-J strata), being ranked higher than REALIZE-MORPHEME and DEP[voice]-Y in the grammar.

4.3.4.7. Evidence for multiple I-O faithfulness interaction: hybrid compounds

Fukazawa, Kitahara and Ota (1998) and Fukazawa (1999) further provide empirical evidence to support their multiple I-O faithfulness analysis. The concept is crucial in explaining the occurrence and non-occurrence of rdk in ‘hybrid’ compounds (see 2.6.2.), where two elements from different strata are compounded. For example, in a [F(oreign) + Y(amato)] hybrid compound supootu-gappa (supootu ‘sports’ + kappa ‘raincoat’) ‘sport raincoat’, *[p] (prohibition of a nongeminate, voiceless bilabial [p] in Y and S-J) is violated in the F first element supootu (where [p] surfaces singly), while *[p] is satisfied in the Y second element -gappa where rdk takes place. This is accounted for only by assuming two different I-O faithfulness constraints are simultaneously active. A more relevant example for the present discussion is a hybrid complex compound like mise-zimai-seeru (/mise/ ‘store’ + /simai/ ‘closing down’ + /seeru/ ‘sale’) of [[Y+Y]+F]]
right-branching structure.

(76) Hybrid complex compound: /mise + simai + seeru/ ‘closing down sale’

1) /mise + simai/ (Y+Y) → [mise-zimai] (+rdk)
2) /mise + simai + seeru/ (Y+Y+F) → [[mise-zimai]-seeru]] (-rdk)

Two types of DEP-IO faithfulness on the association line configuration: DEP[assoc.]-F and DEP[assoc.]-Y are necessary to account for the occurrence of rdk in the first [Y+Y] compounding 1), and the non-occurrence of rdk in the [Y+F] compounding in 2). Two relative rankings, REALIZE-MORPHEME &gt; DEP[assoc.]-Y and DEP[assoc.]-F &gt; REALIZE-MORPHEME, must be simultaneously present (77)

(77) Multiple IO faithfulness constraint interaction in a hybrid complex compound of [Y+Y+F]: /mise/ + /simai/ + /seeru/ → [[mise-zimai] seeru]]

<table>
<thead>
<tr>
<th>/mise + simai + seeru</th>
<th>DEP[assoc.]-F</th>
<th>REALIZE-MORPHEME</th>
<th>DEP[assoc.]-Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [mise-zimai-seeru]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [mise-simai-seeru]</td>
<td></td>
<td>**!</td>
<td></td>
</tr>
<tr>
<td>c. [mise-zimai-seeru]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. [mise-simai-zeru]</td>
<td>*!</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Without two different IO faithfulness constraints for Y and F, a case like this cannot be accounted for.

4.3.4.8. Summary

To summarize, rdk is characterized by the following ranking hierarchy (78-1) and (78-2):
Chapter 4 – Rendaku in Optimality Theory

(78-1) Stratified Hierarchy for Rdk and LL:

\[
\begin{align*}
& \text{OCP}[+\text{voice}, -\text{son}] \quad \Rightarrow \quad \text{MAX[assoc.]} \\
& \text{UNIFORMITY[voice]-M} \quad \Rightarrow \quad \text{REALIZE-MORPHEME} \quad \Rightarrow \quad [+\text{voice}, -\text{son}] \\
& \text{UNIFORMITY[voice]-G} \\
& \text{DEP[assoc.]} \\
& \text{DEP[voice]}
\end{align*}
\]

(78-2) Stratified Hierarchy for Stratum-Specificity of rdk in Y Japanese:

\[
\text{DEP[assoc.]-S-J, M, F, A} \quad \Rightarrow \quad \text{REALIZE-MORPHEME} \quad \Rightarrow \quad \text{DEP[assoc.]-Y}
\]

4.3.5. Structural conditioning of rdk and Output-Output faithfulness

Recall RBC (3.4.1.), the structural condition that restricts rdk to a right branching constituent at the lowest level of a right-branching complex compound. Rdk is observed only in \( [\text{muri-gasa} \ i\text{re}] \) ‘case for lacquered umbrella’ where the compound is right-branching (cf. \( [\text{muri} \ [\text{kasa-ire}] \) ‘umbrella case which is lacquered’). A different analysis is required because in light of work in syntax-phonology interface (e.g. Selkirk 1984) there should be no direct reference in phonology to morphological/syntactic composition except ‘interface’ constraints (or alignment constraints in OT). One solution to this problem associated with such morphologically complex compounds has been offered in the concept of ‘output-output (OO-) correspondence of faithfulness’ (e.g. Benua 1995, McCarthy 1995, Itô and Mester 1997, Burzio 1997). The general principle is that voicing is blocked in \([A[BC]]\) because \([BC]\) is a constituent of type \text{WORD} that occurs independently; thus, it does not show compound voicing. It gives priority to
corresponding ‘free’ forms over ‘bound’ forms. This OO-identity constraint is referred to as \textbf{OO-IDENT[word]} (Itô and Mester 1998:43) given in (79).

\begin{equation}
\text{(79) \quad OO-IDENT[word]: A bound form of type Word is identical to its corresponding free form.}
\end{equation}

As shown schematically in (80) below, the correspondence relation holds between the segments of the phonological exponent of every constituent W(ord) inside a morphological construction (i.e. \( \ldots [x'' y'' z'']_w \ldots \)) and the phonological exponent of the free form of W (i.e. \([x'y'z']_w \)).

\begin{equation}
\text{(80) \quad \textbf{OO}: Ident-Word}
\end{equation}

\begin{center}
\begin{tabular}{l}
\text{phonological input:} \quad x' y' z' \quad \ldots \quad x'' y'' z'' \quad \ldots \\
\text{morphological input:} \quad [x' y' z']_w \quad [\alpha \sim [x'' y'' z'']_w \sim \beta]_w
\end{tabular}
\end{center}

The obtained ranking in (81) now explains the presence/absence of rdk in both \([nuri-gasa \ ire] ‘case for lacquered umbrella’\) and \([nuri [kasa-ire]] ‘umbrella case which is lacquered’\).

\begin{equation}
\text{(81) \quad OO-IDENT[word] \gg REALIZE-MORPHEME \gg * [+voice, –son]}
\end{equation}

The example (23) is reanalyzed in the following tableaux: (82) and (83).
Chapter 4 – Rendaku in Optimality Theory

(82) \([\text{nuri} + [\text{kasa} + \text{ire}]] \) \(\text{nuri-kasa-ire}\) ‘umbrella case which is lacquered’

In (82), \(\text{kasa-ire}\) is the WORD constituent of \(\text{nuri-kasa-ire}\) (‘umbrella case which is lacquered’), and the initial voiceless [k] in \(\text{kasa-ire}\) is not affected through correspondence with the independent output form \(\text{w[kasa ire]}\). Candidate \(\text{w[nuri w[gasa ire]}\) fatally violates \(\text{OO-IDENT[word]}\) and loses. In contrast, \(\text{w[nuri kasa ire]}\) below is the WORD constituent of the whole compound \(\text{w[nuri kasa ire]}\); the losing candidate is \(\text{w[nuri kasa ire]}\) in which \(\text{kasa}\) is not the reference output for \(\text{OO-IDENT[word]}\).

(83) \(([\text{nuri} + \text{kasa}] + \text{ire}] \) \(\text{nuri-gasa-ire}\) ‘case for lacquered umbrella’

In addition, for \(\text{rdk}\) to apply in simple compounds, we need the faithfulness constraint \(\text{OO-IDENT[stem]}\) ranked below \(\text{SEQVOI}\) as in (84) so that the free occurring stem/word such as \(\text{kasa}\) does not block \(\text{rdk}\) in \(\text{nuri-gasa}\).
(84)  \( \text{OO-IDENT[word]} \gg \text{REALIZE-MORPHEME} \gg \text{OO-IDENT[stem]} \)

<table>
<thead>
<tr>
<th>Reference output: ( p_{\text{wd}}(kasa) )</th>
<th>( \text{OO-IDENT[stem]} )</th>
<th>( \text{REALIZE-MORPHEME} )</th>
<th>( \text{OO-IDENT[stem]} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{w[nuri kasa]} )</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{w[nuri gasa]} )</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

4.3.6. Summary

This section looked at how the relevant constraint ranking can account for rdk and the long-standing problem of stratum-specificity of the phenomenon. The universality of the constraint \( \text{REALIZE-MORPHEME} \) has been well attested, and if the junctural morpheme \( p \) bearing underlying [voice] is present in the input (e.g. /ori + \( p \) + kami/), the ranking of constraints in (85) should assure rdk to occur in the \( Y \) stratum of the language.

(85)  The overall stratified hierarchy for rdk in the \( Y \) Japanese (final):

\[
\begin{align*}
\text{[OCP[+voice, -son]} & \gg \text{[MAX[assoc.]} & \gg \text{REALIZE-MORPHEME} & \gg \text{[+voice, -son]} \\
\text{[UNIFORMITY[voice]-M] & \gg \text{[MAX[voice]}} & \gg \text{\text{MORPHEME} & \gg \text{[UNIFORMITY[voice]-G]} \\
\text{[DEP[assoc.]-S,J,M,F,A] & \gg \text{[DEP[voice]}} & \gg \text{[DEP[voice]} & \gg \text{[OO-IDENT[stem]} \\
\text{[OO-IDENT[word]}} & \gg \text{[OO-IDENT[stem]}}
\end{align*}
\]
4.4. Learnability and Acquisition in OT

4.4.1. Introduction

This section briefly outlines the theory's key assumptions and requirements on both learnability and acquisition. The predictions made by OT have largely been borne out in a growing number of case studies that seem to support the view that OT solutions are superior to those offered by rule-based approach in a number of respects. As McCarthy (2002:209) points out,

Explaining the course of phonological development has always been a serious and possibly insurmountable challenge to rule-based phonology. The problem is quite basic: early child phonology seems to involve many more rules than the target adult phonology, including many rules that are not supported by the adult models. If rules are acquired by learners who are outfitted only with a general theory of rule formation and some sort of rule-acquisition device, where do all these early rules come from and where do they go later on? Except for the general theory of rule formation and phonological representations, the learner is supposed to be a tabula rasa whose grammar should only contain rules that can be induced from the adult models. Even the most basic observations about child phonology show that this prediction is very far off the mark. For that reason, empirical research on child phonology and research on phonological theory prior to OT rarely intersected.

(McCarthy 2002:209)

According to McCarthy (2002:208), the theory makes certain basic predictions about language learnability and acquisition as summarized in (86).
OT’s basic predictions about language acquisition.

(1) **Continuity.** Developing grammars and mature grammars are made out of the same stuff — universal CON, GEN, and EVAL — so there should be no qualitative differences between child grammars. Concretely, every process or restriction at work in acquisition should also be possible in the synchronic grammars of adults.

(2) **Typology.** Grammars, whether in the children or adults, are permuted rankings of the constraints in CON. As a kind of corollary to continuity, the developmental stages in children’s grammars ought to mimic the diversity seen in language typology. And if the [M > F] initial state is assumed, then the developmental steps ought to show demotion of markedness constraints along the way.

(3) **Ranking.** In language learning, one grammar replaces another. Since OT grammars are constraint hierarchies, learning involves re-ranking, perhaps via constraint demotion.

(4) **Violability.** Constraints are violable, but violation is minimal. A constraint that is demoted in the course of acquisition may still be visibly active in some circumstances, since demotion is no guarantee of inactivity.

(5) **Emergence of the unmarked.** Developing grammars may show the effects of processes for which there is no evidence in the adult model. This is an expected consequence of the universality of CON.

(6) **Homogeneity of target/heterogeneity of process.** Different developing grammars (different children or different stages in the development of one child) may satisfy the same output target in different ways.

(7) **Richness of the base.** OT shifts the emphasis from learning a lexicon to learning a grammar. This may have implications for the *comprehension/production dilemma*, in which children’s ability to perceive is often far in advance of their ability to produce.

(McCarthy 2002:208)

Our task largely concerns the following three predictions: (a) the process of acquisition is presumed to proceed by the re-ranking of constraints, specifically by the minimal
demotion of markedness constraints by the Constraint Demotion (‘CD’) algorithm (Tesar and Smolensky 1996, 1998, 2000) to arrive at the full rdk grammar, (b) the empirically-motivated prediction of the initial ranking: ‘markedness constraints over faithfulness constraints’ ([M>F]), (c) diversity in the paths of acquisition, particularly on incorrectly internalized input representations and different ‘immature’ misrankings.

Each of these predictions will be dealt with in the following three sections. First, the principle of CD is introduced by means of a brief demonstration on how its key ideas work in the learning of OT grammar, using real rdk data. The second section focuses more on the acquisition of rdk by presenting a simulation of multi-stage rdk development starting from the initial state [M>F] and a particular algorithm called Biased Constraint Demotion (‘BCD’ for short) (Prince and Tesar 1999). The final section considers four alternative learning paths. They are all unlikely but possible learning scenarios in which some ungrammatical outputs could result due to incorrectly inferred rankings due to erroneous input-output mappings.

4.4.2. The Constraint Demotion Algorithm: learning of the ‘target’ rdk ranking

One of the core assumptions of the theory is that all grammars are essentially language-specific hierarchies of universal and violable constraints. In this view, the process of language acquisition equates learning of a constraint hierarchy of the target language grammar, specifically via re-ranking of relevant constraints. This leads to the development of a learning principle known as Constraint Demotion (CD), the basis for
group of ‘algorithms’ such as *Recursive Constraint Demotion* (RCD) algorithm (Tesar and Smolensky 1996, 1998, 2000), which are presumed to deduce relevant constraint rankings from linguistic forms. A nontrivial assumption about the learning theory is that the ‘input’ and ‘output’ are already given, and that the input → output mapping and the inaudible structure of the output is already known to the learner. The algorithm demonstrates that it is possible to construct rankings on the basis of the given input and output forms (= ‘linguistically structured’ representations), provided a given set of universal constraints. The working principle of the algorithm is that the constraints violated in the optimal output must be ‘dominated’ by some other constraints. Cross examination of the attested output form vs. the suboptimal candidates, or the ‘loser/winner’ pairs, provides key information on the identification of constraints involved, and the known pairing of the output to the input leads the way to deduce the relevant hierarchy of constraints consistent with the given data. In the remainder of the section we will learn the key principles and operations of the algorithm and see how it deduces the target rdk ranking using real data from Japanese.

**The initial hierarchy \( \mathcal{H}_0 \)**

This is how the RCD algorithm works. Let us start from the initial state of the algorithm (87) in which all constraints \( C_1 \) to \( C_n \) are in one ‘stratum’ indicated by ‘{ }’, unranked with respect to one another. That is, all constraints are undominated. A hierarchy is conventionally notated as \( \mathcal{H} \), and the initial state as \( \mathcal{H}_0 \).
(87) Initial state of the constraints hierarchy $\mathscr{H}_0$:

$\{C_1, C_2, C_3, \ldots, C_n\}$

In the case of rdk the initial state should look like the following (88).

(88) The initial constraint hierarchy for rdk $\mathscr{H}_0$:

$\{OCP[+\text{voice}, -\text{son}], *[+\text{voice}, -\text{son}], \text{REALIZE-MORPHEME}, \text{MAX[voice]}, \text{MAX[assoc.]}, \text{DEP[voice]}, \text{DEP[assoc.]}, \text{UNIFORMITY[voice]}, \ldots\}$

• **Step 1 $\mathscr{H}_0 \rightarrow \mathscr{H}_1$**

Let us first take the simplest rdk case *ori-gami* as an example to see how the first ranking is initiated on the basis of the given surface form. The task of the algorithm is “to deduce the constraint hierarchy under which the given surface form emerges as the optimal output of the given input form” (Kager 1999:301). That is, to find the ranking that makes the given surface form *[ori-gami]* the most harmonic output of the given input /ori + p + kami/. The critical information on which the algorithm relies is a list of constraint violations for *mark-data pair(s)*. It is a pair of suboptimal/optimal (loser/winner) candidates, in our case *[ori-kami] $\prec$ [ori-gami]. The algorithm then constructs a list of constraint violations made by the suboptimal candidate and the optimal candidate as exemplified below in (89).
(89) Mark-data (Step 1): orikami ≪ origami

\[
\begin{array}{|c|c|c|c|}
\hline
\text{input} & \text{suboptimal} \prec \text{optimal} & \text{loser-marks} (C_{\text{loser}}) & \text{winner-marks} (C_{\text{winner}}) \\
\hline
/ori+p+kami/ & orikami \prec origami & \text{*REALIZE-MORPHEME} & \text{*MAX[assoc.]} \\
\text{[v]} & & \text{*MAX[assoc.]} & \text{*DEP[associ]} \\
\hline
\end{array}
\]

constraints
violated by the loser

Here, a constraint violation is marked by an asterisk (**') before the name of the constraint. \textit{Loser-marks} (C_{\text{loser}}) list all the violation marks of the suboptimal candidate, while \textit{winner-marks} (C_{\text{winner}}) list all the violation marks of the optimal candidate. Any pair that carries information shared by the loser and winner is of no value and must be 'cancelled (or struck) out'. This method is called \textit{Mark Cancellation} (90) first introduced by Prince and Smolensky (1993), which is applied to the violations of MAX[assoc.] in (89).

(90) Mark Cancellation

For each pair (loser-marks, winner-marks) in mark-data:

a. For each occurrence of a mark \text{*C} in both loser-marks and winner-marks in the same pair, remove that occurrence of \text{*C} from both.

b. If, as a result, no winner-marks remain, remove the pair from mark-data.

c. If, after the preceding steps, a row of the mark-data table contains multiple tokens of the same type of mark, duplicates are eliminated, leaving at most one token of each type.

(Kager 1999:306-7)
Now, all the necessary information is ready for RCD to operate. The remaining uncancelled marks are to be relatively ranked according to the principle of constraint demotion (Tesar and Smolensky 2000:36) given in (91).

(91) Principle of Constraint Demotion:
For any constraint $\mathbf{C}$ assessing an uncancelled winner mark, if $\mathbf{C}$ is not dominated by a constraint assessing an uncancelled loser mark, demote $\mathbf{C}$ to immediately below the highest-ranked constraint assessing an uncancelled loser mark.

(Tesar and Smolensky 2000:36)

It orders that all the constraints violated by winners must be dominated by some constraints violated by losers, i.e., $\text{loser-marks} \succ \text{winner-marks}$:

loser-marks: $\mathbf{C}_{\text{loser}}$ (constraints violated by loser)

$\succ$

winner-marks: $\mathbf{C}_{\text{winner}}$ (constraints violated by winner).

So, RCD finds in (89) the highest-ranked $*\mathbf{C}_{\text{loser}}$ in the loser-marks in $\mathcal{H}$, which is $\text{REALIZE-MORPHEME}$. Next, (91) orders that for each $*\mathbf{C}_{\text{winner}}$ in the winner-marks if $\mathbf{C}_{\text{loser}}$ does not dominate $\mathbf{C}_{\text{winner}}$ in $\mathcal{H}$, demote constraint $\mathbf{C}_{\text{winner}}$ to the position immediately below that of $\mathbf{C}_{\text{loser}}$ creating a stratum if it does not already exist. So, the marks are checked to see if any of the winner-marks $\text{DEP[voice]}$, $\text{DEP[assoc.]}$ and $*[+\text{voice}, -\text{son}]$ are dominated by $\text{REALIZE-MORPHEME}$. Since none of them are already
dominated by the loser-marks in the current hierarchy $H_0$, all of them are demoted immediately below $\text{REALIZE-MORPHEME}$ creating a new stratum. The resulting hierarchy $H_1$ looks like (92) after Step 1, an encounter with the datum origami.

(92) The constraint hierarchy $H_1$ (after step 1)

$\{\text{OCP}[+\text{voice},-\text{son}], \text{REALIZE-MORPHEME}, \text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}], \text{UNIFORMITY}[\text{voice}]\}$

$\Rightarrow$

$\{\text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], *[+\text{voice},-\text{son}]\}$

Note that within a stratum constraints are in ‘stratified partial order’. They are non-conflicting and therefore unrankable and unranked with respect to one another. This means that in a stratified hierarchy like $\{C_1, C_3\} \gg \{C_2\}$, although the algorithm could return a stratified partial order $\{C_1, C_3\} \gg \{C_2\}$, the only crucial ranking could just be $\{C_1\} \gg \{C_2\}$ where the interaction between only $C_1$ and $C_2$ (and not $C_3$ and $C_2$) is observed in the language. In other words, the language may provide no evidence for a complete ranking.

In principle, learning should proceed by ‘demoting’ $C_{\text{winner}}$ rather than ‘promoting’ $C_{\text{loser}}$. In this way, RCD is guaranteed to always find some hierarchy consistent with the given data. RCD is ‘recursive’ in the sense that it is repeated until no further demotions occur. In addition, reranking is allowed only if there is ‘positive evidence’ in the form of a constraint violation on the optimal output.

- Step 2

In fact, there are eleven more steps (mark-data pairs) needed to reach the target rdk
grammar via RCD. This section looks at only three of them just to illustrate how further demotions are achieved. The full steps will be shown in the next section in order to simulate several learning scenarios used in constructing a hypothetical acquisition model of rdk.

Now, suppose the learner with the ranking $\mathcal{H}_1$ is exposed next to the datum *yaki-soba* where rdk is blocked due to the OCP. There are several suboptimal output candidates, and we will consider only one of them here: the OCP-violating [*yakizoba*]. This particular mark-data pair [*yakizoba*] $\prec$ [*yakisoba*] motivates a further reranking. The mark-data is constructed as in (93).

(93) Mark-data: [*yakizoba*] $\prec$ [*yakisoba*] (step 2)

<table>
<thead>
<tr>
<th>input</th>
<th>suboptimal $&lt;$ optimal</th>
<th>loser-marks</th>
<th>winner-marks</th>
</tr>
</thead>
</table>

The loser-mark *OCP[+voice, -son] is the highest-ranked in the current ranking $\mathcal{H}_1$. Since REALIZE-MORPHEME is not dominated by *OCP[+voice, -son] it is demoted to the stratum immediately below *OCP[+voice, -son]. The new ranking $\mathcal{H}_2$ is obtained.
The constraint hierarchy $\mathcal{H}_2$ (after step 2)

{OCP[+voice, -son], MAX[voice], MAX[assoc.], UNIFORMITY[voice]}

$\Rightarrow$

{REALIZE-MORPHEME}

$\Rightarrow$

{DEP[voice], DEP[assoc.], *[+voice, -son]}

This reranking from $\mathcal{H}_1$ (92) to $\mathcal{H}_2$ (94) underlines a very important idea about RCD: minimal demotion. Observe that REALIZE-MORPHEME is not demoted all the way down to the bottom of the hierarchy to become dominated by all the constraints in the loser-marks. It is only demoted immediately below OCP[+voice, -son], creating a stratum of its own immediately above {DEP[voice], DEP[assoc.], *[+voice, -son]}. The demotion is minimal. To illustrate the idea, consider the demotion of $C_{\text{winner}}$ in hierarchy (a) below where two alternative rankings (b) and (c) can result:

(a) 

\[
\begin{align*}
\{C_{\text{loser-1}}, C_{\text{winner}}\} & \quad \Rightarrow & \quad \{C_{\text{winner}}\} \\
\{C_{\text{loser-2}}, C_{\text{loser-3}}\} & \quad \Rightarrow & \quad \{C_{\text{loser-2}}, C_{\text{loser-3}}\}
\end{align*}
\]

(b) ✔

(c) ✗

\[
\begin{align*}
\{C_{\text{loser-1}}\} & \quad \Rightarrow & \quad \{C_{\text{loser-1}}\} \\
\{C_{\text{loser-2}}, C_{\text{loser-3}}\} & \quad \Rightarrow & \quad \{C_{\text{winner}}\}
\end{align*}
\]

When the constraints in loser-marks: $C_{\text{loser-1}}, C_{\text{loser-2}}, C_{\text{loser-3}}$ are in different strata as in (a), the demotion of $C_{\text{winner}}$ is always minimal in that it is only demoted immediately
below the highest-ranking loser-mark $C_{loser-1}$, and the resulting hierarchy looks like (b), not (c).

- **Step 3**

The final demotion we consider takes place when the form *tabi-bito* is encountered. The optimal candidate in this step is the one which the two [voice] features are fused into one to obey the OCP. The following mark-data pair (95) can be constructed.

(95) **Mark data: [tabi-hito] ∼ [tabi-bito] (step 3)**

<table>
<thead>
<tr>
<th>input</th>
<th>suboptimal ∼ optimal</th>
<th>loser-marks</th>
<th>winner-marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>/tabi + p + hito/</td>
<td>tabi-hito &lt; tabi-bito</td>
<td>*REALIZE-MORPHEME             *UNIFORMITY[voice]-G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[v]</td>
<td>*MAX,[assoc. -]               *MAX,[assoc. -]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**[+voice, —son]           **[+voice, —son]</td>
<td></td>
</tr>
</tbody>
</table>

REALIZE-MORPHEME is the highest-ranking loser-mark, and it already dominates all the constraints in the winner-marks except UNIFORMITY[voice]-G. So, UNIFORMITY[voice] is demoted immediately below REALIZE-MORPHEME to share the lowest stratum with DEP[voice] and the rest. This results in the new ranking in (96).
(96) The constraint hierarchy $H_3$ (after step 3)

\[
\{\text{OCP}[+\text{voice}, -\text{son}], \text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}], \text{UNIFORMITY}[\text{voice}]-\text{M}\} \\
\Rightarrow \\
\{\text{REALIZE-MORPHEME}\} \\
\Rightarrow \\
\{\text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], \text{UNIFORMITY}[\text{voice}]-\text{G}, *[+\text{voice}, -\text{son}]\}
\]

To complete the basic rdk ranking, we include in the hierarchy $H_3$ the crucial ranking that gives rise to LL: $\{\text{OCP}[+\text{voice}, -\text{son}]\} \Rightarrow \{\text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}]\}$ ("Y stems must not contain more than one voiced obstruent"). As a matter of fact, learning LL should be one of the earliest steps a learner takes as it is the basic morpheme structure constraint in the Y morpheme class. This LL ranking is initiated by a mark-data pair like /buda/ (hypothetical) $\rightarrow$ [buda] $\prec$ [buta] ('pig') (see (102) for the mark-data). The learning process converges into the following hierarchy $H_4$ which is the target ranking of the adult rdk grammar.

(97) The constraint hierarchy $H_4$: the target rdk ranking

\[
\{\text{OCP}[+\text{voice}, -\text{son}], \text{UNIFORMITY}[\text{voice}]-\text{M}\} \\
\Rightarrow \\
\{\text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}]\} \\
\Rightarrow \\
\{\text{REALIZE-MORPHEME}\} \\
\Rightarrow \\
\{\text{DEP}[\text{assoc.}], \text{DEP}[\text{voice}], \text{UNIFORMITY}[\text{voice}]-\text{G}, *[+\text{voice}, -\text{son}]\}
\]
We have seen how RCD successfully accomplishes the task of arriving at a stable target ranking by a set of mark-data pairs, and how the key principles about RCD and assumptions in OT are necessary to make RCD workable. Our next task is to construct a hypothetical developing grammar model for the case of rdk acquisition. In order to do this, we need to make a crucial adjustment to the initial state of the grammar, which has been shown to be capable of catering for certain empirical phenomena observed in phonological acquisition. It is the bias in the initial state, i.e. \([\text{Markedness constraints} \gg \text{Faithfulness constraints}]\).

4.4.3. Rdk Acquisition in OT

4.4.3.1. Child acquisition of phonology and an ‘Initial State’ \([\text{M} \gg \text{F}]\)

One of the most significant and influential predictions of OT that links the formal learnability arguments and empirical studies of phonological acquisition concerns the “initial state” of the grammar, characterized by \([\text{M} \gg \text{F}]\): “the dominance of markedness constraints over faithfulness constraints” (faithfulness constraints should be assigned a default location at the bottom of the constraint hierarchy) – otherwise certain languages would not be learnable (e.g. Smolensky 1996a, b). A number of studies analyzing data in child phonological acquisition (in both first and second languages) within the OT framework (e.g. Gnanadesikan 1995; Demuth 1995; Pater and Paradis 1996; Smolensky
1996a; Levelt and Van de Vijver 1998; Bernhardt and Stemberger 1998) provide empirical support for this assumption. For example, many production errors that occur in early stages of development (i.e. productions containing only unmarked outputs followed by inclusion of progressively more marked ones) have been well characterized by the biased default ranking. The 'subset problem' (e.g. Baker 1979) has also found a solution in the \([M \gg F]\) configuration for the initial state of the grammar. The subset problem refers to the long-standing puzzle of how the learner manages to get from a superset of the target language (i.e. all the grammatical forms in the target language plus some ungrammatical forms not in the target language) to a subset of the language (i.e. all the grammatical forms in the target language) with only positive evidence. If the child develops a linguistic system that generates a superset language, the child will not be able to know only from parental input that anything is wrong. How, then, can learners, if they start from unranked initial state, manage to learn phonotactic patterns, that are unsupported by alternations, without 'negative evidence', i.e. what is 'not' present in the primary data, and subsequently reach the adult grammar? By biasing the initial ranking towards the subset language, learning can proceed towards the superset language only on the basis of positive evidence.

4.4.3.2. Extensions of the initial state \([M \gg F]\)

Smolensky (1996a, b) argues that by starting with \([M \gg F]\), CD gradually mixes the faithfulness and markedness constraints, but markedness constraints would only be demoted below faithfulness constraints to the extent necessary. Further attempts have
been made to either reconfigure the RCD or to refine the initial configuration [M>F] by adding further biases and principles to assure more stringent and tight developing grammars suited to achieve certain tasks successfully in phonological learning. These include ‘Low-Faithfulness Constraint Demotion’ (Hayes 1999), ‘Ranking Consistency’ and ‘Ranking Conservatism’ principles (Itô and Mester 1999), and ‘Biased Constraint Demotion’ (Prince and Tesar 1999).

One of the central ideas in these proposals is that the asymmetry between markedness and faithfulness constraints identified in the initial state [M>F] could also be inherited as a working principle of an algorithm or a durable guiding force of developing grammar itself. Probably the strongest version of the idea is the Biased Constraint Demotion (‘BCD’) Ranking algorithm proposed by Prince and Tesar (1999). The learning algorithm has an intrinsic, constant ‘markedness-favouring’ property maximally preserving the initial state – that is, markedness constraints are ranked ‘as high as possible’ and faithfulness constraints ‘as low as possible’ – throughout learning at each step.

In order to obtain a more refined model of developing grammars in rdk acquisition, the next section will follow each (hypothetical) stage of development using the BCD algorithm by briefly referring whenever necessary to some of the main principles that crucially differ from the simple RCD. This time around, it is assumed that the initial state is [M>F].
4.4.3.3. Arriving at the target grammar via BCD ranking algorithm

Learners are assumed to begin with the initial state $H_0$: [$M \gg F$] to work their way towards the target grammar (85). As we will see, there are several intervening hypothetical grammars identified by each ranking, from $H_0$ to $H_6$ (MF). Each ranking determined by BCD from $H_0$: [$M \gg F$] is indicated by $H_{X(MF)}$, $H_{Y(MF)}$, ..., and so on.

- **Stage 0: an initial hierarchy $H_0$**

To start, we have an initial [$M \gg F$] structure on the markedness and faithfulness constraints for rdk among others as in (98).

\[(98)\quad \text{The initial hierarchy: } H_0 [M \gg F] \]

\[
\{\text{OCP}[-\text{voice}, -\text{son}], *[-\text{voice}, -\text{son}], M_3, M_4, \ldots, M_n\} \\
\gg \\
\{\text{REALIZE-MORPHEME}, \text{MAX}[\text{voice}], \text{DEP}[\text{voice}], F_4, F_5, \ldots, F_k\}
\]

- **Step 1 ('permitting voiced obstruents')**

Input such as *buta* ('pig') must be fed to the grammar first as part of the learning of (phonemic) contrasts and phonotactic patterns before any knowledge of alternation and morphology are realized. This is step 1 (99) in which voiced obstruents come to be permitted in the language. This is shown in two forms of presentation. First, in (99-a) we have the familiar mark-data; (99-b) is called *comparative tableau*, a more compact form of presentation of the same data that we will use from now on (its advantage will become evident later). In the comparative tableau the left two columns contain the input
and data pair: a loser on the left and a winner on the right. In this case, [buta] is the
winner (optimal output for the input /buta/), and *[puta] is a loser (suboptimal output).
Violations are indicated by ‘L(oser)’ or ‘Winner’ in the cells below the names of the
constraints. ‘L’ means that the constraint is a ‘loser-favouring’ constraint that favours
some losers, meaning it is violated by winners (= winner-mark). ‘W’ indicates a
‘winner-favouring’ constraint that favours some winners, i.e. violated by losers (= loser-mark).

(99)

(a) Mark data: /buta/ → [puta] < [buta] (step 1)

<table>
<thead>
<tr>
<th>input</th>
<th>suboptimal &lt; optimal</th>
<th>loser-mark</th>
<th>winner-mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>/buta/</td>
<td>puta &lt; buta</td>
<td>*MAX[voice]</td>
<td>**[+voice, -son]</td>
</tr>
</tbody>
</table>

(b) Comparative tableau /buta/ → [puta] < [buta] (step 1)

<table>
<thead>
<tr>
<th>Loser</th>
<th>Winner</th>
<th>*[+voice, -son]</th>
<th>MAX[voice]</th>
</tr>
</thead>
<tbody>
<tr>
<td>puta</td>
<td>buta</td>
<td>L</td>
<td>W</td>
</tr>
</tbody>
</table>

The case in (99-b) is a clear conflict in which ‘L’ and ‘W’ both occur in the same row.
MAX[voice] is a winner-favouring constraint that is violated by the loser [puta] due to
the deletion of the [voice] feature, whereas *[+voice, -son] is a loser-favouring
constraint that is violated by the winner [buta] by its voiced obstruent. Any constraints
that favour some losers must be dominated by constraints that only favour winners:
‘W’ > ‘L’. The winner-favouring MAX[voice] conflicts with *[+voice, -son] and must
be ranked above it. One of the basic principles of the BCD states that “F-constraints should be ranked only if they “conflict” (i.e. when ‘W’ and ‘L’ both occur in the same row) with other constraints”. This modification to RCD principle is called Faithfulness Delay (Prince and Tesar 1999:13) given in (100).

(100) Faithfulness Delay:

On each pass, among those constraints suitable for membership in the next stratum, if possible place only markedness constraints. Only place faithfulness constraints if no markedness constraints are available to be placed in the hierarchy.

(Italics original; Prince and Tesar 1999:13)

So, the ranking of faithfulness constraints is delayed until there are no markedness constraints to be ranked in the hierarchy. According to (99), the markedness constraint $^*_{[-\text{voice}, -\text{son}]}$ has to be dominated by $\text{MAX}[\text{voice}]$. Now, where should $^*_{[-\text{voice}, -\text{son}]}$ be ranked? The way BCD ranks $^*_{[-\text{voice}, -\text{son}]}$ crucially differs from the way RCD does. BCD functions to maximally preserve the $M \gg F$ domination relation throughout. Compare the initial state below, where a list of $M(arkedness)$ constraints dominating all the $F(aitfulness)$ (Prince and Tesar 1999:16):

$$
\{M_1, M_2, \ldots, M_n\} \gg \{F_1, F_2, \ldots, F_k\}.
|\leftarrow M \rightarrow| |\leftarrow F \rightarrow|
$$

Suppose an encountered datum requires $F_1 \gg M_1$. We know that RCD demotes $M_1$ to the highest possible stratum, a new one at the bottom, conserving as much as possible of the current hierarchy:
\{M_2, \ldots, M_n\} \succ \{F_1, F_2, \ldots, F_k\} \succ \{M_1\}

The problem with this ranking is that \(M_1\) is now dominated by the whole set of faithfulness constraints, greatly upsetting the \(M \succ F\) domination relation. On the other hand, the same relation of \(F_1 \succ M_1\) is expressed by BCD in the following hierarchy:

\{M_2, \ldots, M_n\} \succ \{F_1\} \succ \{M_1\} \succ \{F_2, \ldots, F_k\}

In this way, BCD constantly reinforces a minimal dominance of \(F\) over \(M\). Therefore, the hierarchy after Step 1 (99) is obtained as (101). All hierarchies resulting from the biased initial state \(M \succ F\) are marked \(\mathcal{H}_{(MF)}\) hereafter.

(101) The constraint hierarchy \(\mathcal{H}_{1(MF)}\) (after step 1)

\[
\begin{align*}
\{\text{OCP}[+\text{voice}, -\text{son}], M_2, M_3, \ldots, M_n\} \\
\succ \\
\{\text{MAX}[\text{voice}]\} \\
\succ \\
\{*[+\text{voice}, -\text{son}]\} \\
\succ \\
\{\text{REALIZE-MORPHEME, DEP}[\text{voice}], F_3, F_4, \ldots, F_k\}
\end{align*}
\]

- **Step 2** ('disallowing two voiced obstruents per \(Y\) morpheme: LL')

The second datum to be considered is the hypothetical /buda/ given earlier.
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(102) Comparative tableau: /buda/ → [buda] < [buta] (step 2)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>buda &lt; buta [v]</td>
<td>W</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>buda &lt; buta [v]</td>
<td>W</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

This indicates that MAX[voice] and *+[voice, -son] favour only losers, while OCP[+voice, -son] and UNIFORMITY[voice] favour only winners. So, following the M > L relation, MAX[voice] and *+[voice, -son] are demoted below OCP[+voice, -son] and UNIFORMITY[voice]. The markedness OCP[+voice, -son] remains where it is, and the faithfulness UNIFORMITY[voice] has to be placed into the hierarchy to dominate both MAX[voice] and *+[voice, -son]. This gives a new hierarchy shown below in (103):

(103) The constraint hierarchy \( \mathcal{H}_{2(MF)} \) (after step 2)

\[
\{\text{OCP}[+\text{voice}, -\text{son}], M_2, M_3, \ldots, M_n\} \\
\supset
\{\text{UNIFORMITY[voice]}\} \\
\supset
\{\text{MAX[voice]}\} \\
\supset
\{*[+\text{voice}, -\text{son}]\} \\
\supset
\{\text{REALIZE-MORPHEME, } F_2, F_3, \ldots, F_k\} \\
\]
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The first two steps are characterized by the lowest-ranked (i.e. inactive) REALIZE-MORPHEME in the grammars. In order for the learner to learn the alternation, the current hierarchy (103) has to be further reranked to account for rdk. This is the next step.

• Step 3 (‘learning of the alternation’)
The learner entering this stage (and beyond) must be already capable of recognizing the rdk [+voice] morpheme p in underlying forms. The learner now encounters the first piece of evidence [ori-gami] (‘folding paper’) signaling the rdk alternation. The morphological analysis of the given datum enables the learner to correctly map /ori + p + kami/ as the most harmonic input. This is step 3 portrayed below in (104):

(104) Comparative tableau: /ori + p + kami/ → [ori-kami] < [ori-gami] (step 3)

<table>
<thead>
<tr>
<th>Loss &lt; Winner</th>
<th>REALIZE-MORPHEME</th>
<th>DEP[voice]</th>
<th>DEP[assoc.]</th>
<th>*[+voice, -son]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ori-kami</td>
<td>W</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>[v]p</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In tableau (104) REALIZE-MORPHEME prefers only winners and the rest of the constraints favour only losers. The markedness *[+voice, -son] is in conflict with REALIZE-MORPHEME and must be demoted immediately below REALIZE-MORPHEME to occupy the position along with MAX[voice] (since the two are currently unrankable to each other). The loser-favouring faithfulness constraints DEP[voice] and DEP[assoc.] are placed in the hierarchy and reside at the bottom as in (105).
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(105) The constraint hierarchy: $H_3(MF)$ (after step 3)

\[
\{ \text{OCP}[^{+}\text{voice}, -\text{son}] M_2, M_3, ..., M_n \} \\
\{ \text{UNIFORMITY}[\text{voice}] \} \\
\{ \text{MAX}[\text{voice}], \text{REALIZE-MORPHEME} \} \\
\{ ^{*}[^{+}\text{voice}, -\text{son}] \} \\
\{ \text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], F_3, F_4, ..., F_k \}
\]

- **Step 4** (‘LL in action’)

The datum encountered in step 4 is [yaki-soba]. Rdk is blocked in (106-a) to obey the OCP within the stem \{soba\}. Neither the fusion of \[+\text{voice}\] feature (106-c) or devoicing of the underlying \[+\text{voice}\] (106-b) are the right way to obey the OCP.

(106) Comparative tableau /yaki + p + soba/ $\rightarrow$ [yaki-soba] (step 4)

<table>
<thead>
<tr>
<th>Loser $\prec$ Winner</th>
<th>OCP</th>
<th>REALIZE-MORPHEME</th>
<th>UNIFORMITY</th>
<th>MAX [voice]</th>
<th>MAX [assoc.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. yaki-zoba $\prec$ yaki-soba</td>
<td>W</td>
<td>L</td>
<td></td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>b. yaki-zopa $\prec$ yaki-soba</td>
<td>L</td>
<td></td>
<td></td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>c. yaki-zoba $\prec$ yaki-soba</td>
<td>L</td>
<td>W</td>
<td></td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>d. yaki-soba $\prec$ yaki-soba</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td>W</td>
</tr>
</tbody>
</table>

It is clear that REALIZE-MORPHEME must be dominated by all the constraints because all other constraints favour only winners. The dominance of the OCP and
UNIFORMITY[voice] over REALIZE-MORPHEME is already present in the current hierarchy. The clear conflict in (106-d) is most informative. So, REALIZE-MORPHEME must be placed below MAX[assoc.] and MAX[voice]. This yields the following ranking as shown in (107).

(107) The constraint hierarchy: $\mathcal{H}_{4(MF)}$ (after step 4)

\[
\{OCP[+\text{voice}, -\text{son}], M_2, M_3, \ldots, M_n\} \\
\overset{>}{\longrightarrow} \\
\{\text{UNIFORMITY[voice]}\} \\
\overset{>}{\longrightarrow} \\
\{\text{MAX[voice]}, \text{MAX[assoc.]}\} \\
\overset{>}{\longrightarrow} \\
\{\text{REALIZE-MORPHEME}\} \\
\overset{>}{\longrightarrow} \\
\{*[+\text{voice}, -\text{son}]\} \\
\overset{>}{\longrightarrow} \\
\{\text{DEP[voice]}, \text{DEP[assoc.], F}_3, F_4, \ldots, F_k\}
\]

- **Step 5** ('the M/G split of UNIFORMITY[voice]; completion of the ranking')

The learner next encounters a comparatively rare compound of [tabi-bito] type. It signals that the fusion of two adjacent [voice] features across the morpheme boundary is allowed. This triggers the split of UNIFORMITY[voice] into UNIFORMITY[voice]-G(eneral) ("no [voice] fusion in domain larger than a morpheme") and UNIFORMITY[voice]-M(orpheme) ("no [voice] fusion within a morpheme").
In tableau (108), UNIFORMITY[voice]-G favours only losers and all the other constraints only favour winners. It is clear that UNIFORMITY[voice]-G is placed in the lowest stratum of the hierarchy to be dominated by OCP[+voice, -son], REALIZE-MORPHHEME and MAX[voice]. MAX[assoc.] favours both winners and losers and cannot be placed from this data, and stays where it is. The original UNIFORMITY[voice] has to be newly-specified for two different domains as UNIFORMITY[voice]-G and UNIFORMITY[voice]-M. The resulting ranking after step 5 is shown in (109).

(109) The constraint hierarchy $\mathcal{H}_5^{(MF)}$ (after step 5)

\[
\begin{align*}
\{ \text{OCP}[+\text{voice}, -\text{son}], M_2, M_3, ..., M_n \} \\
\quad \Rightarrow \\
\{ \text{UNIFORMITY}[\text{voice}]-\text{M} \} \\
\quad \Rightarrow \\
\{ \text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}] \} \\
\quad \Rightarrow \\
\{ \text{REALIZE-MORPHHEME} \} \\
\quad \Rightarrow \\
\{ *[+\text{voice}, -\text{son}] \} \\
\quad \Rightarrow \\
\{ \text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], \text{UNIFORMITY}[\text{voice}]-\text{G}, F_4, ..., F_k \}
\end{align*}
\]
This completes the demonstration of BCD operation in constructing the full rdrk ranking based on one plausible data order. The next section considers other alternative 'detour' learning paths – with altered data orders – from which certain non-surface-true outputs result. All scenarios involve temporary ill-ranked hierarchies constructed by incorrectly inferred inputs from incorrectly perceived surface forms.

4.4.4. Alternative learning paths: the ‘worst case’ scenario

What has just been sketched above is only one of several logically possible learning scenarios under one learning order. As regards McCarthy’s ‘homogeneity of target/heterogeneity of processes’ in (86-6), it has been widely acknowledged that the path of acquisition is widely diverse, as different children seem to follow different development orders in different contexts (Gnanadesikan 1995; Levelt and Van de Vijver 1998; Levelt, Schiller and Levelt 1999; Barlow and Gierut 1999; Boersma and Levelt 2000). For example, Levelt and Van de Vijver (1998) report on the development of syllable types in children acquiring Dutch that the relative frequency effect appears to determine the child’s choice of which path to follow among various possibilities. This means that different forms of intermediate developmental grammars can exist in any one time of the overall course of acquisition. Then, it is fair to ask whether any more alternative routes can be added to the development scenario.

In the following sub-sections, four types of unlikely but logically possible
learning scenarios will be simulated by hypothesizing alternative language-particular learning orders. This may be caused by factors like low frequency in and/or inconsistency of rdk in the key data in child-directed speech. All the scenarios are “worst-case” imaginable in a sense that the key data signaling the constraint reranking are given in a way so that the learner is lured into setting up an incorrect hypothesis about the input-output mappings. The main purpose of these simulations is to predict (a) which type of output is expected and which is not, (b) intermediate forms of grammar that produce forms that are not expected, and (c) to see what extent can the actual data on rdk development is best modeled by OT.

First is the underapplication of rdk resulting from the ‘unrelativized’ UNIFORMITY[voice] (i.e. unspecified for any particular domain size) placed higher than it is desired. This is called the **Strong UNIFORMITY[voice] problem.** This ill-formed grammar bans voice fusion anywhere in the compound so that it fatally rules out the desired output [tabi-bito]. Rdk is therefore underapplied when the input type is [tabi + ρ + hito]. Second, the devoicing of underlying [voice] is obtained from the same hierarchy from the same effect expressed by UNIFORMITY[voice] but on a different type of input. One of the underlyingly voiced obstruents in the /tabi + gara/ type input is devoiced to obey the OCP; the wrong winners are either of *[tabi-kara] type or *[tahi-gara] type. It is the case of over-extension of the OCP or LL effect. Third is the **Weak UNIFORMITY[voice] problem,** the reversed version of the above, which is the only circumstance that causes the violation of LL, namely the overapplication of rdk, logically possible. Again, the unrelativized UNIFORMITY[voice] is responsible, but this time it is ranked lower than it should be. This allows the wrong winner *[yaki-zoba] with the two [voice] features fused to surface. Finally, the *pseudo-rdk* phenomenon is
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a prediction about the children’s deceptively surface-true +rdk forms which stem from the underlying rdk [+voice] in the input that is parsed at the surface. In this type of grammar \textsc{realize-morpheme} is not yet ranked and therefore inactive. All the scenarios shown below are marked by ‘\(\Theta\)’ to indicate the worst case imaginable.

4.4.4.1. The ‘Strong’ UNIFORMITY[voice] problem and the ‘underapplication of rdk’:

\[
/\text{tabi} + p + \text{hito}/ \rightarrow *[\text{tabi-hito}]
\]

This scenario is based on the suspicion that not all learners infer successfully the two different domain sizes: M(orpheme) and G(eneral) for UNIFORMITY[voice]. Of course the learner already knows that no [voice] fusion is permitted within the domain of Y stem since this constraint came into the hierarchy in Step 2 (e.g. *[buda] in (102)). Nevertheless, the ‘M/G split’ may not be confirmed until it is decisively signaled by the presence of two pieces of data: \textit{yaki-soba} (“no [voice] fusion within the morpheme”) and \textit{tabi-bito} (“[voice] fusion allowed across two morphemes”) together suggesting that the same constraint has to cater for two distinct domains. The danger for the learner is that hearing only one of the pieces of data does not necessarily trigger the split, and that to stay in this immature state, that is, \(H_3(MF)\) (after Step 3 – (96)) and \(H_4(MF)\) (after Step 4 – (107)), can produce ungrammatical outputs. We will call this problem the \textit{Strong}\n
\textit{UNIFORMITY[voice]} (110) as the effect of the constraint is expressed more strongly than the target ranking and bans [voice] fusion indiscriminately.
First, we will consider the case of underapplication of rdk, which is predictable during the transition phase between $\mathcal{H}_4(MF)$ and $\mathcal{H}_5(MF)$ (after Step 5 - (109)). This is when the learner knows [ori-gami] (Step 3 in the normal data order) and [yaki-soba] (Step 4), but not [tabi-bito] (Step 5). This means that this learner has already acquired the rdk alternation and LL, but not yet the UNIFORMITY[voice]-M/G split. When the learner produces a compound from two forms /tabi/ ('travel') and /hito/ ('person'), this makes the /tabi + p + hito/ type input, and the intermediate grammar always yields outputs that contain at most one voiced obstruent. In other words, any candidate that contains more than one segment bearing [voice] feature cannot surface. Tableau (111) shows that this grammar incorrectly chooses [tabi-hito] as the winner.

(111) 'Underapplication of rdk': /tabi + p + hito/ $\rightarrow$ *[tabi-hito]

<table>
<thead>
<tr>
<th>/tabi + p + hito/</th>
<th>OCP [+voi,-son]</th>
<th>UNIFORMITY[voice]</th>
<th>REALIZE-MORPHEME</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [tabi + hito]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>[v] [v]</td>
<td>[v] [v]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [tabi + bito]</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[v] [v]</td>
<td>[v] [v]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [tabi + bito]</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[v] [v]</td>
<td>[v] [v]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is the underapplication of rdk because, having the voice fusion disallowed
anywhere in the bi-morphemic output, rdk is always blocked and obeys the OCP[+voice, -son].

4.4.4.2. The ‘Strong’ UNIFORMITY[voice] problem and the ‘devoicing of underlying [voice]’: /tabi + p + gara/ —> *[tabi-kara] or *[tahi-gara]

The same problem of the Strong UNIFORMITY[voice] (110) can also cause the devoicing of one of the underlying voiced obstruents to satisfy the OCP when the input is of /tabi + gara/ type. The expected outputs are either *[tabi-kara] or *[tahi-gara]. Consider tableau (112).

\[(112) \text{‘Devoicing of underlying [voice]’: } /\text{tabi } + \text{p} + \text{gara}/ \rightarrow *[\text{tabi-kara}] \text{ or } *[\text{tahi-gara}]\]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [tabi + gara]</td>
<td>![v] [v] ![v]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. [tabi + gara]</td>
<td>![v] [v] ![v]</td>
<td>*!</td>
<td>**</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. [tabi + gara]</td>
<td>![v] ![v] ![v]</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d. [tahi + gara]</td>
<td>![v] ![v] ![v]</td>
<td>***</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. [tahi + gara]</td>
<td>![v] ![v] ![v]</td>
<td>**</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. [tabi + kara]</td>
<td>![v] ![v] ![v]</td>
<td>**</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<desired output>
<wrong winner>
<wrong winner>
Under this immature ranking, (112-c) [tabi-gara], the desired output is incorrectly and fatally penalized (indicated by ‘∗!’) by the strong UNIFORMITY[voice] that has no domain stipulation of M(orpheme), and both (112-e) *[tahi-gara] and (112-f) *[tabi-kara] become the wrong winners because they obey the OCP not only by blocking the rdk [+voice], but also by devoicing one of the underlying [+voice]. Since the ranking disallows [voice] fusion regardless of domain size, the optimal candidate of this grammar always has only one voiced obstruent at the surface. The result is that if the input already contains two adjacent [voice] underlingly, one of them has to be devoiced to surface. This is another result of the Strong UNIFORMITY[voice] problem.

4.4.4.3. The ‘Weak’ UNIFORMITY[voice] problem and the ‘overapplication of rdk’:

/yaki + p + soba/ → *[yaki-soba]

It has been predicted that when the normal learning path is followed, the violation of LL such as *[yaki-zoba] should not occur. However, reversing the feeding order of the two pieces of data yaki-soba and tabi-bito (Step 4 (107) and Step 5 (109) in the normal learning order) has a significant consequence. This could prompt the learner to construct an undesirable ranking that suffers from the Weak UNIFORMITY[voice] problem which obtains when the general UNIFORMITY[voice] is ranked below REALIZE-MORPHEME before UNIFORMITY[voice]-M comes into the hierarchy to dominate it. We simulate this case from $\mathcal{H}_3$ (MF) (after Step 3: [ori-gami]), given earlier as (105), in which rdk alternation has just been learned. The ranking is reproduced in (113):

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(113) The constraint hierarchy: $\mathcal{H}_{3(MF)}$ (after step 3) (repeated from (105))

\[
\{\text{OCP}[+\text{voice}, -\text{son}] M_2, M_3, \ldots, M_n\}
\rightarrow
\{\text{UNIFORMITY}[\text{voice}]\}
\rightarrow
\{\text{MAX}[\text{voice}], \text{REALIZE-MORPHEME}\}
\rightarrow
\{*[+\text{voice}, -\text{son}]\}
\rightarrow
\{\text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], F_3, F_4, \ldots, F_k\}
\]

We reversed the original data order, and give [tabi-bito] prior to [yaki-soba]. We have seen in (108) that [tabi-bito] is supposed to signal the following relationship: \text{REALIZE-MORPHEME} \gg \text{UNIFORMITY}[\text{voice}]-G. Since the split of \text{UNIFORMITY}[\text{voice}] into M and G is signalled most logically by the original order, and most certainly by the presence of both pieces of data, it may be the case that some learners mistakenly internalize the ranking – not knowing that the [voice] fusion is domain-relative – and demote \text{UNIFORMITY}[\text{voice}] below \text{REALIZE-MORPHEME}. The resulting hierarchy is shown in (114). This is the Weak \text{UNIFORMITY}[\text{voice}] problem.

(114) The Weak \text{UNIFORMITY}[\text{voice}] problem:

\[
\text{OCP}[+\text{voice}, -\text{son}] \gg \text{REALIZE-MORPHEME} \gg \text{UNIFORMITY}[\text{voice}]
\]

This ranking is characterized by the reversed effect of the Strong version. The unrelativized \text{UNIFORMITY}[\text{voice}] is under-ranked and hence 'weak'. Then, given the
input of /yaki + soba/ type, as in (115), this grammar lets (115-c) [yaki-zoba] surface. This is the case of overapplication of rdk, or the violation of LL.

(115) ‘Overapplication of rdk’: /yaki + p + soba/ ➞ *[yaki-zoba]

<table>
<thead>
<tr>
<th>Input</th>
<th>OCP [+voice, -son]</th>
<th>REALIZE-MORPHEME</th>
<th>*[+voice, -son]</th>
<th>Uniformity [voice]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [yaki + zoba]</td>
<td>*!</td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. [yaki + soba]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [yaki + zoba]</td>
<td></td>
<td></td>
<td>**</td>
<td>*</td>
</tr>
</tbody>
</table>

This case provides an important theoretical indication that LL violation is logically possible without violating the OCP. In fact, the OCP-violating candidate (115-a) never stand a chance of surfacing at any stage of acquisition since the markedness constraint OCP[+voice, –son] always resides at the highest stratum throughout.

4.4.4.4. Children’s incorrect underlying forms and ‘pseudo-rdk’

This is not necessarily a bad scenario as all the outputs are grammatical and identical to adult forms. The real issue concerns the source of the rdk voicing. As the name suggests, the pseudo-rdk phenomenon refers to the hypothesis that under certain circumstances the rdk in the surface-true output may not be phonologically ‘genuine’. As we know, phonologically genuine rdk is produced by the linking rdk morpheme p in the input and the relevant constraint ranking involving REALIZE-MORPHEME. The pseudo-rdk, on the
other hand, is not produced in this way. It comes from the underlyingly [+voice] obstruent already present in the input. Compare (116-a) and (116-b) below.

(116)

(a) ‘Pseudo-rdk’

/origami/ ➞ [origami]

(b) ‘Genuine rdk’

/ori+[v]p+kami/ ➞ [origami]

Although the pseudo-rdk form and the genuine rdk form are phonetically identical, (116-a) has the full-representation input, i.e. morphologically unanalyzed lexical item. This is an incorrectly internalized underlying form and the output is the exact copy of it. This incorrect but fully-harmonic mapping gives rise to the non-genuine rdk. The only situation in which (116-a) is likely to occur is under $\mathcal{H}_{2}^{(MF)}$ (after step 2), the immature rdk hierarchy (103) that has not yet learned the alternation. The ranking is repeated below as (117):

(117) The ‘pseudo-rdk’ ranking: $\mathcal{H}_{2}^{(MF)}$ (after step 2) (repeated from (103))

$$
\{\text{OCP}[^{+}\text{voice}, ^{-}\text{son}], \ldots\} \\
\quad \gg \\
\{\text{UNIFORMITY}[\text{voice}]\} \\
\quad \gg \\
\{\text{MAX}[\text{voice}]\} \\
\quad \gg \\
\{^{*}[^{+}\text{voice}, ^{-}\text{son}]\} \\
\quad \gg \\
\{\text{REALIZE-MORPHHEME}, \ldots\}
$$

Since the surface form structure is not correctly analyzed and the linking rdk morpheme
is not recognized, REALIZE-MORPHEME remains unranked and hence ‘inactive’ in the hierarchy. This is not very surprising because the learner at this stage is expected to be immature and lack relevant knowledge to learn the alternation (see 6.3.1.1. for a discussion on the possible motivation behind this phenomenon). In any case, the learner in the state of $H_{2}(MF)$ treats a given rdk form as an unstructured whole, and assigns an incorrect but fully faithful input to it. The modified tableau in (118) illustrates how the mapping /origami/ → [origami] is achieved when the learner hears [origami].

(118) The ‘pseudo-rdk’ output-input mapping: [origami] ↔ /origami/

<table>
<thead>
<tr>
<th>Candidates</th>
<th>Structures</th>
<th>Grammar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td>Surface form</td>
<td>OCP</td>
</tr>
<tr>
<td>a. ori+p+kami/ [origami]</td>
<td>[v]p</td>
<td>*</td>
</tr>
<tr>
<td>b. /origami/ [origami]</td>
<td>[v]</td>
<td>*</td>
</tr>
</tbody>
</table>

The surface form is given and it is [origami]. What is different from production is that there are two competing candidate inputs, and they — among many other possibilities — are freely and universally afforded by ROTB. The competing candidate structures are now those that are pronounced [origami]. Now, the principle of lexicon optimization (Prince and Smolensky 1993) induces the learner to select from the candidate set the most harmonic input for the given surface form. The decision between (118-a) and (118-b) is passed to the lowest ranking faithfulness DEP[voice], which decisively rules out (a) due to the insertion of [+voice] (the fatal violation is marked “i” in contrast with production). Lexicon optimization chooses (b) /origami/ → [origami] as the most
faithful parse (the winner is marked "∗" in contrast with production), which gives rise to the pseudo-rdk phenomenon. This is true for any given compound as long as the grammar has the hierarchy $H_2^{MF}$ and the given form is regarded as a single unanalyzed lexical form (without linking morpheme $p$).

### 4.4.5. Summary

We set out with the question of what the rdk acquisition process would look like. With the OT conception of language learnability and acquisition, particularly the initial state hypothesis $H_0: [M \gg F]$, BCD algorithm, and the final ranking of the adult rdk grammar, we have constructed a hypothetical 'prototype' developing-grammar model for rdk. The five pieces of data have been considered in five steps resulting in five intermediate hierarchies from $H_0^{MF}$ to $H_5^{MF}$. This sequential development can be captured more simply by the relative ranking relations between $*[+\text{voice}, -\text{son}]$ and REALIZE-MORPHEME and the UNIFORMITY[voice] split. As shown in (119), $*[+\text{voice}, -\text{son}]$ has been demoted successively in the course of reranking, from the highest position (Step 0) to the lowest (Step 3 onwards) which is the final resting position. The split of UNIFORMITY[voice] has been considered to occur in the final step, which completes the full rdk hierarchy.
Successive $[^{+}\text{voice}, ^{-}\text{son}]$ demotion in the full rdk hierarchy:

\[
\begin{align*}
\{\text{OCP}[^{+}\text{voice}, ^{-}\text{son}]\} & \quad \text{Step 0} \\
\rightarrow & \quad \{\text{UNIFORMITY}[^{+}\text{voice}]-\text{M}\} \quad \text{('M/G split' Step 5)} \\
\rightarrow & \quad \{\text{MAX}[^{+}\text{voice}], \text{MAX}[\text{assoc.}]\} \quad \text{Step 1,2} \\
\rightarrow & \quad \{\text{REALIZE-MORPHHEME}\} \\
\rightarrow & \quad \{[^{+}\text{voice}, ^{-}\text{son}]\} \quad \text{Step 3, 4, 5} \\
\rightarrow & \quad \{\text{DEP}[^{+}\text{voice}], \text{DEP}[\text{assoc.}], \text{UNIFORMITY}[^{+}\text{voice}]-\text{G}\}
\end{align*}
\]

This gives us four distinctive types of grammar (i.e. the triple $[^{+}\text{voice}, ^{-}\text{son}]$ demotions and the UNIFORMITY[^{+}\text{voice}] split) that crucially differ in the type of outputs they produce. Let us identify each of them as $\mathcal{L}_0$, $\mathcal{L}_1$, $\mathcal{L}_2$ and $\mathcal{L}_3$. The initial grammar $\mathcal{L}_0$ (Step 0) may be called the VOP ("no voiced obstruent") grammar for it does not permit voiced obstruents. This is undoubtedly the very early stage of acquisition of the language. The next grammar $\mathcal{L}_1$ is characterized by the ranking $[^{+}\text{voice}, ^{-}\text{son}] \gg \text{REALIZE-MORPHHEME}$ (unranked). It comprises two stages (Step 1 and 2), and the latter is called the pseudo-rdk grammar since it does not give rise to the genuine rdk in the outputs (i.e. no $[^{+}\text{voice}]_p$ surfaces). All the rdk outputs from this grammar are expected to be surface-true.

The grammar $\mathcal{L}_2$ (hierarchies $\mathcal{H}_3(MF)$ and $\mathcal{H}_4(MF)$) is potentially problematic. When neither yaki-soba nor tabi-bito trigger the UNIFORMITY[^{+}\text{voice}] domain specification of M and G, we expect the Strong UNIFORMITY[^{+}\text{voice}] problem, from
which the underapplication of rdk and the devoicing of underlying [voice] occur. When tabi-hito is encountered prior to yaki-soba, contrary to the normal learning order, this can prompt the learner to construct the ill-formed ranking called the Weak UNIFORMITY[voice] (denoted by $\mathcal{L}_{2}^{\text{M}[\text{voice}]}$ and $\mathcal{L}_{2}^{\text{G}[\text{voice}]}$ respectively). This is the only scenario in which the violation of LL (e.g. [yaki-zoba]) is possible due to the [voice] fusion. This overapplication of rdk is caused by the UNIFORMITY[voice] being ranked lower than desired (i.e. below REALIZE-MORPHEME) that it is too weak to ban the [voice] fusion within the morpheme {soba}. Compared to the target ranking, these grammars typically show the following domination relations that can produce various unwanted outputs:

1) Target domination relation of $\mathcal{L}_{F}$ (M/G split of UNIFORMITY[voice])

\[
\{\text{UNIFORMITY[voice]-M}\} \gg \{\text{REALIZE-MORPHEME}\} \gg \{\text{UNIFORMITY[voice]-G}\}
\]

2) The Strong UNIFORMITY[voice] grammar: $\mathcal{L}_{2}^{\text{M}[\text{voice}]}$ (H$_{3}^{(\text{MF})}$, H$_{4}^{(\text{MF})}$)

\[
\{\text{UNIFORMITY[voice]}\} \gg \{\text{REALIZE-MORPHEME}\}
\]

Results in –

the underapplication of rdk: /tabi + p + hito/ → *[tabi-hito]

the devoicing of underlying [voice]: /tabi + p + gara/ → *[tabi-kara] / *[tahi-gara]
3) **The Weak UNIFORMITY[voice] grammar**: \(L_2\otimes_{W}\)

\{REALIZE-MORPHEME\} \(\Rightarrow\) \{UNIFORMITY[voice]\}

Results in –

the overapplication of rdk: /yaki + p + soba/ \(\rightarrow\) *[yaki-zoba]*

The grammar \(L_5\) (after Step 5) is the **full rdk grammar** for it represents the knowledge of rdk of an ideal adult speaker.

The expected outputs from each of the grammar types are summarized below in Table 2. These result from the input types given in the left-most column (the bold letters denote segments bearing underlying [+voice]). Cells in gray contains erroneous outputs (indicated by ‘\(\otimes\)’).

<table>
<thead>
<tr>
<th>Table 2. Sequential changes of grammars and expected outputs for the given input types (<em>‘(\otimes)’ indicates ill-formed rdk grammar and opaque output</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input type</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>/hasi + hako/</td>
</tr>
<tr>
<td>/ori + kami/</td>
</tr>
<tr>
<td>/yaki + soba/</td>
</tr>
<tr>
<td>/tabi + hito/</td>
</tr>
<tr>
<td>/hana + gara/</td>
</tr>
<tr>
<td>/tabi + gara/</td>
</tr>
</tbody>
</table>

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For example, when the learner is in grammar $L_{2\otimes_{W}}$, an input, say, /toke $+$ keda/ (nonexistent), which is of /yaki $+$ soba/ type, is expected to surface as [toke-geda], and this is an unwanted output. Conversely, if the learner produces [toke-geda], we can speculate that the grammar is $L_{2\otimes_{W}}$.

To conclude the chapter, the sequential development of rdk hierarchies are shown below in (120).

(120) Sequential development of rdk hierarchies

\[ \mathcal{H}_{0}(MF) \text{ (Step 0)} \]

- The initial state: $[M \gg F]$

\[
\{ \text{OCP}[+\text{voice}, -\text{son}], *[+\text{voice}, -\text{son}], \ldots \}
\]

\[
\Rightarrow
\{ \text{REALIZE-MORPHEME, MAX[voice], DEP[voice],} \ldots \}
\]

\[ \mathcal{H}_{1}(MF) \text{ (after step 1)} \]

- $\mathcal{L}_{0}$: Voiced obstruents permitted

\[
\{ \text{OCP}[+\text{voice}, -\text{son}], \ldots \}
\]

\[
\Rightarrow
\{ \text{MAX[voice]} \}
\]

\[
\Rightarrow
\{ *[+\text{voice}, -\text{son}] \}
\]

\[
\Rightarrow
\{ \text{REALIZE-MORPHEME, DEP[voice],} \ldots \}
\]
**Chapter 4 — Rendaku in Optimality Theory**

\[ \mathcal{H}_2^{(MF)} \text{ (after step 2)} \]
\[
\{ \text{OCP[+voice, -son]} \} \supset
\{ \text{UNIFORMITY[voice]} \} \supset
\{ \text{MAX[voice]} \} \supset
\{ \ast[+\text{voice}, -\text{son}] \} \supset
\{ \text{REALIZE-MORPHEME} \}
\]

- **\( \mathcal{L}_1 \):** OCP in Y stem
  (at most one voiced obstruent per Y stem)

- **Pseudo-rdk '⊗'**

\[ \mathcal{H}_3^{(MF)} \text{ (after Step 3: [ori-gami])} \]
\[
\{ \text{OCP[+voice, -son]} \} \supset
\{ \text{UNIFORMITY[voice]} \} \supset
\{ \text{MAX[voice]} \}, \text{REALIZE-MORPHEME} \supset
\{ \ast[+\text{voice}, -\text{son}] \} \supset
\{ \text{DEP[voice]}, \text{DEP[assoc.]} \}
\]

- **\( \mathcal{L}_2 \):** The rdk alternation learned

- **The Strong UNIFORMITY[voice] '⊗'**
  \( \mathcal{L}_2^{[\text{sp}]} \):
  (no UNIFORMITY[voice]-M/G 'split')
  the underapplication of rdk: \( \ast[\text{tabi-hito}] \)
  the devoicing of underlying \{voice\}:
  \( \ast[\text{tabi-kara}], \ast[\text{tahi-gara}] \)

\[ \mathcal{H}_4^{(MF)} \text{ (after Step 4: [yaki-soba])} \]
\[
\{ \text{OCP[+voice, -son]} \} \supset
\{ \text{UNIFORMITY[voice]} \} \supset
\{ \text{MAX[voice]}, \text{MAX[assoc.]} \} \supset
\{ \text{REALIZE-MORPHEME} \} \supset
\{ \ast[+\text{voice}, -\text{son}] \} \supset
\{ \text{DEP[voice]}, \text{DEP[assoc.]} \}
\]

- **The Weak UNIFORMITY[voice] '⊗'**
  \( \mathcal{L}_2^{[\text{w}]} \):
  (too weak to ban [-zoba] after the encounter with [tabi-bito])

\[
\{ \text{OCP[+voice, -son]} \} \supset
\{ \text{MAX[voice]}, \text{REALIZE-MORPHEME} \} \supset
\{ \ast[+\text{voice}, -\text{son}], \text{UNIFORMITY[voice]} \} \supset
\{ \text{DEP[voice]}, \text{DEP[assoc.]} \}
\]

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\( \mathcal{H}_s^{(MF)} \) (after Step5: [tabi-bito])

- The 'target' rdk grammar \( \mathcal{L}_\Psi \)

\[
\begin{align*}
\{ & \text{OCP}[+\text{voice}, -\text{son}] \} \\
\quad & \Rightarrow \\
\{ & \text{UNIFORMITY}[\text{voice}]-\text{M} \} \\
\quad & \Rightarrow \\
\{ & \text{MAX}[\text{voice}], \text{MAX}[\text{assoc.}] \} \\
\quad & \Rightarrow \\
\{ & \text{REALIZE-MORPHEME} \} \\
\quad & \Rightarrow \\
\{ & [+\text{voice}, -\text{son}] \} \\
\quad & \Rightarrow \\
\{ & \text{DEP}[\text{voice}], \text{DEP}[\text{assoc.}], \text{UNIFORMITY}[\text{voice}]-\text{G} \}
\end{align*}
\]
Chapter Five

PSYCHOLINGUISTIC ISSUES

5.1. Introduction

Having been provided with the formal description of the process and its prototype learning model, we now turn to two major issues: how our knowledge of language is organized, and how the learning mechanism operates. This is particularly relevant to rdk because its irregular aspect is still largely unexplained. We know that the conditions — including seemingly minor and trivial ones — make the phenomenon irregular, but we do not know how actual speakers deal with them. This chapter attempts to seek for a better understanding of the unsystematic and unpredictable aspects of rdk that make it a highly irregular phenomenon, and to construct a hypothesis about the way rdk is projected in the minds of Japanese speakers.

In order to capture rdk as a part of the actual speaker’s mental organization of linguistic knowledge, it must be couched within a relevant theory, namely UG. The first section takes up the very issue that is one of the most important lines of linguistic
research: **internalism** and the evidence of **psychological reality**. This is followed by a few sections of the chapter looking at some of the key issues in the famous debate of morphological acquisition and processing from the psycholinguistic perspective. An influential theory of the **dual mechanism** posits two qualitatively different cognitive components in our language learning mechanism. It provides ample evidence for the psychological reality of symbolic rules and the role of associative memory, exemplified in a well-known case of English inflectional morphology. The categorical contrast between the regular and irregular past tense verbs offers a vital insight into the psychologically separate mechanisms and dissociable representations of regularity and irregularity. Children’s (as well as adults) **overgeneralization** errors and **U-shaped development** curve are among the most important developmental facts that must be accounted for. The chapter closes with some reviews of acquisition and cognitive literature on the issues of how compounds are learned and represented in the mental lexicon.

### 5.2. The Mentalist Stance and “I-language”

Since Chomsky (e.g. 1968, 1972) proposed that linguistics was to be one indispensable part of cognitive psychology, the ultimate goal of linguistic research has been set on providing a valid theory of an individual speaker-hearer’s actual mental organization of his linguistic knowledge. The idea of language is “a system represented in the mind/brain of a particular individual” (Chomsky 1988:36). This mentalist stance – language is a **psychological phenomenon**: – has been one of the most important and
basic insight of Chomskyan theory of language, known as *internalism*. Its prime object is a language "internal" to the individual, i.e. *I-language*, rather than the language external to individuals, i.e. *E-language*. I-language is a technical term introduced later in Chomsky's work (Chomsky 1986, 1991) to replace the often confusing and frequently misinterpreted term/concept of "competence" – speaker-hearer's knowledge of language (Chomsky 1965). I-language refers specifically to the knowledge of language *Internal* (opposed to 'external') to, or in the mind-brain of, an *Individual* (opposed to 'collective') speaker-hearer. It is *Intensional* (opposed to 'extensional') in that first, what matters is the intensional procedures in which it operates rather than some other external and extensional devices capable of achieving the same result; second, it gives a range of interpretations to every event it is exposed to. Contrasting with I-language is the externalized language, technically referred to as E-language, which is closely related to the conventional term of "performance", but covers a wider, "dubious" domain of linguistic samples viewed as physical and social phenomenon.

Our prime concern is the nature of I-language. It is of paramount importance to display and explain what native speakers know about language and where this knowledge comes from. Since I-language is a mentally represented entity by definition, a research into speaker's competence inevitably involves investigations of evidence of a psychological kind. We cannot look inside one's grammar, but we can at least make a worthy attempt to introspect our own knowledge of language. The ultimate piece of evidence to verify one's hypothesis about I-language is the linguistic *intuitions* or judgments of the native speaker about well-formedness and ill-formedness of the language. Let us consider one simple example from Smith (1999). Anybody who is a native speaker of English judges the sentence *John speaks English fluently*
"grammatical". More importantly, everybody agrees unanimously that *John speaks fluently English* is "ungrammatical". Such intuitional judgment (often called "negative knowledge") has been a hallmark in Chomskyan linguistics that offers the true insight of one’s profound knowledge of his/her own language, and possessing such knowledge is what being a native speaker of the language means. Chomsky is the first to demonstrate the "subtlety" of human command of language, and that it is this "unconscious knowledge" or *tacit knowledge* (e.g. Chomsky 1969) that underlies our ability to speak and understand. Unless you are a linguist or a teacher/student of English grammar, not everyone is able to explain why they know that *John speaks fluently English* is ungrammatical. Some may explain that the sequence of "pronoun-verb-adverb-noun" does not occur in English. However, this explains nothing about the reason why native speakers of English say *John speaks English fluently*, and are still able to make a negative judgment about more complex examples like *This is the man John hired before he spoke to*, which could not have been heard or explicitly taught.

This is the very point of the *Poverty-of-the-Stimulus* argument: "why do we end up knowing more than we have learned?" The answer is that we all have built-in structure of the language faculty from the beginning. This is UG: "the system of principles, conditions, and rules that are elements or properties of all human languages ... the essence of human language" (Chomsky 1975:29). UG is assumed to be "innate", commonly inherited by human beings regardless of which language they speak. UG comprises a set of universal *principles*, a common basis of all human languages, and values for *parameters* that specify the possible and limited choices of variation which language can make. Acquiring a language means setting all the values for parameters appropriately to the language being acquired.
The description of I-language provides clues as to what constitutes knowledge of language. Chomsky (1995:15) hypothesizes that “the I-language consists of a computational procedure and a Lexicon”. Normal humans can produce and understand any of an infinite number of novel forms, phrases and sentences that they have never uttered or heard before. This is done by combining a finite number of simple units using a finite set of symbolic rules. This ability (e.g. Chomsky 1965; Chomsky and Halle 1968; Aronoff 1976; Selkirk 1982) gave rise to the theory that the human language competence comprises of two distinct components: central grammatical knowledge or a combinatorial mental grammar manipulating abstract symbolic representations, and lexical knowledge or the mental lexicon of memorized list of simple units. It would be a misconception to consider that the whole of I-language is innate. UG theory recognizes that there is a core grammatical competence, namely UG, consisting of a set of universal principles and associated parameters and some lexical information on one hand, and additional peripheral knowledge on the other. This includes lexically idiosyncratic forms and other oddities in the lexicon, such as the irregular verbs in English past tense inflection. Such aspects of the language are considered somewhat mysterious in function, peripheral to UG. It follows that what we have to learn from the linguistic inputs we have been directly exposed to is the values for parameters and this peripheral aspect of language. In other words, both genetic and environmental factors lead the way of language acquisition in which the learner internalizes I-linguistic generalizations on the basis of E-linguistic input. Hence, a large part of I-language, i.e. the ‘core grammar’, is innate, but certain parts of it have to be learned. In addition, in some circumstances, certain aspects of a language may be taught explicitly to the learner early enough or consistently enough to become part of one’s I-language, but it is the learner’s
'conscious' knowledge that influences one's linguistic judgments based on social-educational (pedagogical) experiences. For example, some native speakers of English tend to disfavour 'split infinitives' as in *I wanted to sort of hit him* because they were explicitly taught early at school that it is ungrammatical. Similarly, most Japanese children become familiar with the rdk-particular /h/ ~ /b/ voicing alternation along with other voiced ~ voiceless obstruent pairs as soon as they start reading and writing the *kana* syllabaries by means of chart citation. Perhaps some teachers of Japanese feel the need to explain rdk at school, although it is not in the curriculum, as is often the case in foreign language classrooms. Taught knowledge is essentially 'non-linguistic', distinct from the central 'linguistic' knowledge. Hence, a negative judgment based on taught knowledge is not strictly a function of the I-language.

A description of language and language knowledge has nothing but a superficial relationship to the actual speaker's production/perception processes. The fact that all native speakers of Japanese conform to forms like *ori-gami* ('paper folding') and *yaki-soba* ('fried noodles') instead of *ori-kami* and *yaki-zoba* provide no evidence for or against a linguist's hypothesis about the I-language. Such performance data may have resulted from the rule internal to his mental grammar or from a 'frozen' lexical item stored in memory, or perhaps both. In any case, what we are really interested in is not whether *ori-gami* and *yaki-soba* have been said or heard but whether forms like *ori-kami* and *yaki-zoba* could be said, and how would they be judged if they were. However, as mentioned above, searching for hard evidence of psychological nature is not so easy. Much of our linguistic knowledge is complex, not easily accessible to consciousness, and is not always amenable to "personal introspection" as well as "public observation". Intuitional judgments are often considered too ephemeral,
intangible and subjective to be usable, except when they are under experimental control. Then, the biggest challenge for researchers of I-language is a methodological one: considerable methodological ingenuity is needed to make the speaker’s knowledge apparent.

5.3. Psychological Reality

The question of the nature of evidence has been often highlighted in terms of psychological reality (Chomsky 1980). By hypothesis, I-language in our minds is primarily an object with a psychological reality. A piece of evidence is psychologically real when it is “true”. Psychological reality (or unreality) of phonological and morphological processes has attracted wide interest and generated a large volume of literature in the debate over the gap between derivational theories and their psychological evidence. Most of these studies aim to test the question of whether speakers have internalized knowledge of phonological processes as part of their ‘competence’ to test the implicit assumption that speakers have the rules in question stored in their minds. Consequently, hypothesized productive rules have been put to the test in various psycholinguistic experiments. (e.g. Zimmer 1969; Hsieh 1970, 1976; Hale, Bresnan and Miller 1978; Linell 1979; Hayes, 1990; Lima, Corrigan and Iverson 1994; Tsay and Myers 1996, among others). Apart from Berko’s (1958) study which has provided support for the psychological reality of English plural formation, most of the results of psycholinguistic experiments have shown that at least some supposedly productive rules lack psychological reality. The arguments have been concerned not
only with the data themselves but largely with the interpretation of the data and implications for the theory of generative phonology/morphology that these results reflect speaker's 'performance' rather than 'competence'. A well-attested example is the phonological process of Taiwanese Tone Sandhi. It has been argued that this is an epiphenomenon of morpheme alternants in the lexicon rather than a set of 'psychologically real' rules of grammar (Hsieh 1970, 1976; Tsay and Myers 1996). It is certainly true that the output of the grammar is not entirely free from other behavioral and circumstantial factors as well as some extra-grammatical knowledge. Competence/performance tension has always been a concomitant of I-linguistic experiments testing the postulated productive rule. Nevertheless, the only way to offer a synchronic account of rdk is to conduct an I-linguistic investigation to see to whether rdk is a part of psychologically real grammar.

As we have seen in the earlier chapters, the E-linguistic description of rdk clearly shows that it is not a 'unitary' phonological process. It is widely irregular due to a number of conditions. Furthermore, there are different occasions in which rdk is taught explicitly or implicitly to the learner of Japanese. Otherwise, most native speakers seem largely unconscious or uncertain about their knowledge of rdk yet some others seem to have a vague rdk-handling strategy. For instance, the researcher's own judgment about non-existent forms like ori-kami and yaki-zoba (in contrast with ori-gami and yaki-soba) would be that ori-kami is a perfectly acceptable, possible, well-formed compound while yaki-zoba is almost certainly unacceptable, impossible and ill-formed. When it comes to a pair like kutu-himo ('shoelaces') vs. kutu-bimo, where the former is the existing form, a judgment becomes fuzzier: kutu-bimo is judged perfectly possible but less acceptable. It is not at all clear-cut in forms like san-kai and san-gai ('third
Smith and Cormack (2002) propose the idea of *parametric poverty*, a circumstance in which the data is too sparse to assure parameter settings, leaving some parameters indeterminate not only in child language, but in adult language too. Smith and Cormack propose two plausible scenarios: ‘random settings’ and ‘no settings’. Random settings, in which the same parameter is assigned different values on the basis of the same input, is supported by well-known cases in adults language of dialectal and idiolectal differences, such as individual differences in the sequence of tense possibilities. In the following sentences (Smith 2002; Smith and Cormack 2002): *Did you know that Emily is ill?* vs. *Did you know that Emily was ill?*, the authors have split judgments: for one, the former *Did you know that Emily is ill?* is simply ungrammatical, whereas for the other, both are acceptable. This is a case of a randomly fixed parameter. The less orthodox ‘no settings’ is demonstrated by Cowart (1997) (cited in Smith and Cormack 2002) in ‘*that*-trace’ effects in judgments over sentences like *Who do you think (*that*) left* where many informants are widely inconsistent. As mentioned above, these phenomena are extendable to phonology as Yip’s example shows. The researcher’s vacillating judgment over *san-kai* and *san-gai* (‘third floor’) also qualifies as an example of the unset parameter hypothesis where he is simply not sure of his own
intuition. In case of rdk, the controversy over the nature of such judgment is this: “is this a true introspection of one’s grammar or simply a reflection of lexical knowledge, e.g. a matter of frequency or generality in the mental lexicon?”

It is still an open question as to how individual speakers treat rdk, but it is plausible that rdk may not necessarily be part of one’s grammar, i.e. the reflection of the productive rule of grammar. It could be a part of the memory-based knowledge, i.e. some generalizations in the lexicon, which influences the speaker’s judgments on the outputs of the grammar. In order to verify a hypothesis about I-language, one should seek as much evidence as possible. In case the native speaker’s intuitions are not decisive, alternative sources of evidence, namely, external (empirical) evidence must be considered. They include language acquisition, language variation and change, and language pathology. In this way, one can strive for a synchronic account of rdk process and grammar, which are both psychologically acceptable and empirically justifiable.

5.4. Vance (1979)’s Study

There is an important study by Vance (1979) that provides evidence bearing on the psychological status of rdk and some of the proposed conditions on rdk. Vance carried out a set of binary-choice acceptability tests involving nonsense-words designed to test (1) the inhibition effect of rdk in dvandva (coordinate) compound structure, (2) the correlation between type frequency in existing examples and subjects’ rdk production rate, (3) psychological reality of LL, and (4) the rdk-inducing effects of nasals and long vowels in the first constituents. The subjects were 14 linguistically-naïve, native
speakers of Tokyo Yamanote dialects, aged between 22 and 40. All the compound stimuli are presented orthographically, and the task is to choose one of the two pronunciations, either with or without rdk.

The first test is intended as a gross measure of the psychological reality of the rdk inhibiting effect ascribed to dvandva structure. Each stimulus consists of two ‘real’ words in which the second element almost always undergoes rdk. The results show that dvandva structure is not a psychologically real inhibitor of rdk for some speakers: 3 subjects (of 14) chose pronunciations with rdk in every case, 2 without rdk in every case, and most of the others chose some with rdk.

The study further investigates the extent to which the behavior of real second elements in novel combinations can be predicted from their behavior in existing compounds. Each stimulus contains a nonsense first element and real second element. The nonsense items are presented to the subjects as defunct Y words for their phonotactic characteristics, and are explicitly identified as such in the written instructions. The results are as follows:

(1) The number of rdk responses correlates fairly well with the percentage of dictionary examples with rdk. The influence of existing examples with a given 2nd element presumably depends to a large extent on how salient they are, or even more on how frequently they are used especially with rdk pronunciation.

(2) Violation of LL is observed: 88% of the violations on the test items involve the 2nd element *hasigo* “ladder, stairs” which shows rdk in all dictionary examples. Violations on the items with other 2nd elements show the percentage of 2.5% of the opportunities (mean 2.8).

(3) The significant result of the “strong version” of LL is observed. In other words,
speakers may be less inclined to choose a form with rdk when a 1st element ends in a mora with a voiced obstruent; *tado + [real] (mean 57.3) and *hoga + [real] (mean 66.0).

The final test combines real first elements with nonsense second elements. It aims to test the subjects’ preference for rdk in nonsense words. Included are some items for testing the rdk inhibiting effect of ‘verb-verb’ compounds and the rdk inducing effects of the first elements ending in a nasal and long vowel, based on the claim that rdk is most likely after nasals and next most likely after long vowels (Sakurai 1966; Okumura 1980). The results are as follows:

1. LL apparently does not exist as a categorical constraint on rdk for most of the subjects. However, it indicates that a voiced obstruent in the 2nd element of a compound inhibits rdk to some significant extent. The mean percentage across subjects of rdk responses to items with no voiced obstruents in the 2nd element is 64%. A voiced obstruent in the 2nd or 3rd mora of the 2nd element significantly reduces the likelihood of rdk responses: in the 2nd mora is 31%; the 3rd mora: 34%; the 4th mora: 47%.

2. There are no significant rdk-inducing effects of the first elements ending in nasals and long vowels.

3. As for the psychological reality of rdk inhibition in verb-verb compound, the Wilcoxon test indicates that the difference between the means (i.e., 45.4 and 43.7) is not significant at the .05 level.

Vance argues that a word’s pattern of behavior as a 2nd element in existing compounds has a greater influence on responses. LL is clearly not psychologically real for 11 (of 14) subjects, and there are 3 marginal cases. With one exception, a voiced obstruent in the 2nd element of a compound does inhibit rdk to a statistically significant
extent even for those subjects who clearly do not observe the constraint categorically. The wide individual variation in the psychological status of LL among representatives of a largely homogeneous speech community is the most important.

In the following sections, we will look at one influential theory that explicitly acknowledges the dual architecture of our language faculty. The implication of the theory for the analysis of rdk, as has been for other controversial phonological and morphological processes (e.g. Taiwanese Tone Sandhi, Hausa Shortening, English past tense irregular verbs), is that the dichotomy of grammar and the lexicon – rules of grammar and rules in the lexicon – has a psychological and neurolinguistic motivation, and provides a better understanding of such problematic processes in a psychological perspective.

5.5. The ‘Dual Mechanism’ theory

The dual mechanism theory (Pinker and Prince 1988, 1994, Pinker 1991, 1994) – ‘DMT’ for short – is a hypothesis about the cognitive architecture of speaker’s language learning mechanism. It takes the view that two separate and dissociable psychological mechanisms are needed to account for the acquisition and development of inflectional morphology, which has been extensively studied in the area of English past tense formation. Its central claim is that a speaker is equipped with two distinct cognitive mechanisms: symbolic rule operation that governs the production of regular forms, and a type of associative memory network which is responsible for storing and identifying the irregular forms. DMT maintains that the English -ed rule is called regular not
because it applies to the majority of words in the language, but because it operates as a default in a psychological sense, that is, it applies whenever access to memory is unsuccessful (or not possible). A successful access retrieves an irregular form or a pattern that matches it, and blocks the application of -ed rule. Of course, DMT is not the first theory to acknowledge the dichotomy. A basic distinction between the type of information and knowledge represented as ‘rule’, ‘grammar’ and that listed in ‘memory’ and ‘lexicon’ has long been the backbone of many linguistic theories both in the generative literature, where there is a distinction between true productive rules and morpholexical redundancy rules, as well as in psycholinguistic and language acquisition research on regular and irregular inflection. This view is generally known as the traditional “dual-route” account or “rule-&-rote” model particularly in the community of psycholinguistics (e.g. Pinker and Prince 1988). DMT is a modified version of the traditional rule-&-rote theory. What makes DMT particularly unique and influential is its reworking of the traditional view of lexical memory, replacing the idea of rote memory with that of an associative network. The latter is an analogy-based network which not only links words with words but also extracts patterns based on frequency and similarity and makes associations among them.

The significant modification to this traditional rule-&-rote model was called for when the researchers known as the connectionists came up with an alternative learning theory to rules. Connectionism is the study of ‘artificial neural networks’ in the representation, acquisition and grammatical knowledge by means of computational and mathematical techniques. The first model, the well-known ‘Rumelhart and McClelland model’ (Rumelhart and McClelland 1986) was an attempt to generate both regular and irregular past tense forms using a ‘single’ mechanism. This approach is called
connectionist single-route theory which holds no explicit representation of rules. The mechanism behind the past tense is one single component (connection weights, or more technically, 'multilayer backprop net') that handles both regulars and irregulars. The model ('PDP': Parallel Distributed Processing) has attracted widespread interest because the connectionist net imitated some aspects of human linguistic behaviour: not only did it produce correct past tense forms, but also produced correct outputs for novel forms without any reference to symbolic rules. Despite its successful results, the conclusion has been so overstated by Rumelhart and McClelland — in short, rules may be merely convenient approximate fictions — that it provoked considerable controversy and criticism. For Pinker and Prince, among other linguists, this was so “bold and revolutionary” (Pinker and Prince 1988:165), and had to be countered. Pinker and Prince (1988) and Lachter and Bever (1988) were quick to point out that there were numerous flaws with the model. First, it did not account adequately for distinct stages observed in the acquisition process, particularly the way speakers handle irregular patterns (see 5.6.). Secondly, it does not capture sufficiently how people treat regular forms. It failed to freely apply -ed on forms such as jump and pump, yet was lured into incorrect irregularization (see 5.7.) of regular verbs by analogy to other similar irregular verbs previously learned. The critics argued that the kind of rule-like productivity claimed to have been achieved by the model is more of the semi-productive extension of accumulated patterns to novel forms by analogy. Finally, as Daugherty and Seidenberg (1994) put it: “the enormous gap between what the authors claimed to have achieved (a radically new and better theory of the phenomena) and what they had actually achieved (a demonstration of some interesting and suggestive behaviours of a neural net) may explain why the model was so negatively received” (p358). The two
sets of critics have concluded that connectionist models are a mere implementation of the rule-based theory, and could succeed at best as a variant of it.

Some of these problems have been addressed in the later neural networks, and they performed more successfully, with better generalization to novel forms, better account of *U-shaped learning* and *overregularizations* (e.g. Seidenberg 1992; Plunkett and Marchman 1991, 1993; Hare, Elman and Daugherty 1995). The proponents of what came to be known as the DMT have either acknowledged or criticized a series of claims forwarded by the connectionists, but it is true that DMT has evolved largely in response to the development of connectionist models. Two major modifications have been made to the traditional rule-&-rote theory. First, the rote memory system is replaced by associative memory which handles irregulars. Second, it is assumed that generalization is handled by the net, rather than the rule component. Having been developed in the vigorous debate between symbolic vs. connectionist models, DMT has combined the strength of the generative theories in their characterization of productive rules and that of a real insight in to associative memory structure from connectionist theories.

One of the most insightful and fruitful contributions of the development in both theories has been concerned with the characterization of the dynamic associative memory network in handling irregulars (e.g. Marcus et al., 1992; Pinker and Prince, 1994; Plunkett and Marchman, 1991, 1993; Prasada and Pinker 1993; Marcus et al., 1995; Xu and Pinker, 1995; Pinker 1999). The current debate seems to be over the role of “rules”. In attempt to develop a theory of past tense that best accommodates real data, the key question is: does any theory of past tense morphology have to include a rule component? In particular, the *type frequency hypothesis* has been on the agenda to test the assumption that the regular rule, in a psychological sense, should not depend on
frequency. Recent studies suggest, however, that the frequency effects may be common to both regular and irregular inflections (e.g. Baayen et al. 1995 in Orsoloni, et al. 1998; Orsoloni and Marslen-Wilson 1997). Research has been conducted to test DMT cross-linguistically, for example in German (Clahsen et al. 1992; Marcus et al. 1995; Clahsen 1996, 1999), Polish (Dąbrowska 2001), Italian (Orsoloni, and Marslen-Wilson 1997; Orsolini, et al. 1998), Dutch (Baayen, Dijkstra and Schreuder 1997; Baayen, Lieber and Schreuder 1997), Icelandic and Norwegian (Ragnarsdottir, et al. 1996 in Orsolini, et al. 1998). Some of the studies show little or no evidence for the categorical distinction of two systems that DMT claims to exist (the case of German and Polish will be considered later in 5.8.) Then, it is fair to say that currently there seems to be no single model that provides a fully-integrated account of how inflectional morphology is handled by speakers of different languages.

The dual architecture of rule and associative memory is supported by a rich body of psycholinguistic and neurolinguistic evidence. They are painstakingly documented in a series of studies, particularly in Marcus et al. (1995:196-209). They list a collection of 21 various circumstances in support of rules (see 5.8.), and most of these also provide evidence for the dual-route mechanism. A few examples are given below.

First, irregularization errors by children and adults are far less frequent – 0.19% of the time opposed to regularization errors of 4.2% (Marcus et al. 1992; Xu and Pinker 1995), indicating the existence of two fundamentally different components involved in the production of past tense. Secondly, lower-frequency past tense forms are judged less natural-sounding and harder to produce, but this is not the case for regulars (Pinker and Prince 1988); past tense novel forms are more acceptable and easily-inflected if they resemble existing irregulars, but regulars do not show such effects (Pinker and Prince
1994; but see Marchman 1997). Thirdly, children and adults prefer regular past tense forms in novel verb like line-driven over line-driven when drive is used as a noun to mean “to hit a line drive”, but irregular line-driven is preferred when it is a verb to mean “to drive along a line”; this indicates that irregulars are stored as roots (not words), and the mapping is squelched in favor of regular whenever it fails to function as a root, or an entry in the lexicon (Pinker and Prince 1988; Kim et al. 1991). Fourth, both adults and children are sensitive to the constraint that irregular plurals but not regulars, can be contained in a compound as a “non-head” member like mice in mice-infested but not *rats-infested, suggesting that irregulars are stored as roots and hence are subject to derivational morphology (Gordon 1985). Finally, studies on in various neurological disorders suggest that the ability to produce regular and irregular inflections is impaired differently. (Pinker and Prince 1994; Marcus et al. 1995; Pinker 1994, 1999)

In sum, the most important claim of DMT is that the distinction is a psychological and neurolinguistic one; rule is to mean a psychological rule; it is called regular only if it applies as default when access to memory fails; associative memory handles irregulars, stored as links of canonical roots, and is sensitive to frequency and similarity. DMT is probably the most well-studied and well-debated psycholinguistic theory of inflectional morphology to date.

5.6. Irregulars and Pattern-Associative Memory

DMT explicitly acknowledges that regular and irregular inflections are stored and computed differently. Irregular forms are handled by the analogy-based associative
memory network, which is responsible for storing and identifying the *prototype schemas* for the phonological similarities among the forms, linking patterns with patterns as well as words with words. Understandably, the most important characteristic of the associative memory is that it is highly sensitive to frequency and similarity.

One of DMT’s departures from the traditional view of rote memory is to account for the fact that English irregular verb pairs are not simply an unproductive rote list. Pinker (1999:90-91) asks if irregular verbs are truly memorized by rote, how do we explain the following patterning observed in irregular verbs?

1) The similarity between the morphological base forms and their past-tense forms (i.e. *stem-past similarity*). How could rote memory, designed for pairs with unrelated members like *belis*, account for subregular pairs like *drink-drunk* and *swing-swung*?

2) The similarity within the set of base forms undergoing a subregular process (i.e. *stem-stem similarity*). How could rote memory explain the alternation patterns found in a family of phonetically more-or-less similar irregular verbs (e.g. *sing, ring, drink, shrink, stink; keep, creep, deal, feel, mean, dream; grow, throw, know, draw, etc.*)?

3) Semiprodutivity (i.e. *change-change similarity*). Irregular pairs do not seem like a completely unproductive fixed list, but their patterns, e.g. *drink-drunk* ([tɾ]-[æ]-[ʌ]), *keep-kept-kept* ([kɪː]-[e]-[e]), *know-knew-known* ([nau]-[uː]-[au]), can to some degree be extended to new forms. We observe some occasional extension of irregular patterns to existing or nonce stems; errors like *bring-brang* and *bite-bote* from children, and *spling-splung* from adults in experimental tests. Irregulars can also be added to the language diachronically by analogy with existing forms such as *caught, cost* and *stuck*.

(Pinker 1999:90-91)

If rules — descriptively encapsulated as redundancy rules — are to be used to capture the
similarities in ‘patterns’ or ‘conditions’ shared by the words, they miss the important associations people make on “family resemblance” of words. For instance, as Bybee and Slobin (1982) point out, positing a rule on the pattern drink-drunk and spring-sprang has to include incorrectly bring-brought, while mistakenly exclude begin-began and swim-swan, on which the actual mental association would be of drunk – sprang – began – swam type. Pinker and Prince (1994) state on this:

(Pinker and Prince 1994:326)

They argue that their view of the associative memory can capture more adequately the patterns among the irregular verbs than connectionists and a set of minor rules (e.g. Chomsky and Halle 1968). Bybee and Moder (1983) and Prasada and Pinker (1993) suggest that people can treat irregular patterns semi-productively (i.e. ‘irregularization’), not with a rule, but with a prototype schema for the related irregular verbs stored in memory, for example, sCCV[velar nasal] for the string family. Their experiments showed that when adult subjects are asked to produce the past tense form of a novel verb (e.g. to spling), the likelihood of an irregular past tense response (e.g. splung) increases with the phonological similarity of the novel verb to the phonological prototype of an irregular past tense cluster. Furthermore, Xu and Pinker (1995) report that children occasionally use novel irregular past tense forms, like brang for brought,
and truck for tricked. The better a verb matches the prototype, the more likely a speaker will productively extend an irregular pattern to it. This, in turn, means that it is only when a novel item is phonologically similar to existing verbs can properties of listed inflected forms be generalized (Prasada and Pinker 1993). In addition, the links are not all-or-none but of ‘graded strength’ (Marcus et al. 1995:194). In other words, people appear to treat irregular patterns as a kind of graded analogy of gradient strength.

In sum, DMT makes the following predictions on irregular inflections:

1. **Effects of frequency**
   Irregulars as memorized items should be highly frequency-sensitive, but regulars in general should not be. For instance, lower-frequency irregulars are more likely to be overregularized (e.g. broke) by children and to be uttered incorrectly by adults when under time pressure (Bybee and Slobin 1982). Ratings of naturalness for past tense regular verbs correlate significantly with rated naturalness of their stems, but naturalness ratings for past irregulars correlate less strongly with their stem ratings but significantly with frequency. Lower-frequency irregulars are more likely to be overregularized by children (Bybee and Slobin 1982; Marcus et al. 1992);

Second, many regular plurals have developed meanings that do not correspond to the composition of the stem meaning plus plurality (e.g. alms), and they must be stored.

Third, in doublets – having two equally acceptable synonymous regular and irregular alternants such as dived/dove, dreamed/dreamt – the regular forms are likely to be stored and not to be blocked by the existence of the irregular counterparts in memory (see “Overgeneralization” below). A speaker’s judgement on how predictable the irregular forms are depends heavily on frequency of the irregular forms (Ullman and
Finally, frequency makes a small but measurable difference in regular verbs that rhyme with other irregular verbs, such as blink (with drink, stink, etc.) and glide (with ride and stride, etc.). The attraction by analogy of the similar irregulars (e.g. drink, stink) would tempt speakers to expect blank or blunk instead of blinked which appears somewhat unpredictable and surprising (Ullman and Pinker 1990 in Pinker 1999).

Lower-frequency irregulars are more likely to be overregularized by children and uttered incorrectly by adults under time pressure (Bybee and Slobin 1982); in a reaction time experiment, lower-frequency irregulars had a significantly longer response time than higher ones, but no such effect for regulars (Snyder 1990 cited in Pinker and Prince 1994);

(2) **Effects of similarity**

Irregulars should be highly similarity-sensitive, but regulars in general should not be. Irregular patterns are more likely to be extended to a nonce stem the more similar it is to an existing English consonant cluster: spling is inflected as splung more often than spiv is inflected as spuv (Bybee and Moder 1983). For regular verbs, Prasada and Pinker (1993) confirmed in their experiments that no significant generalization gradient occurred. DMT explains the persistence of family resemblance clusters as the product of enhanced retention, and occasional extension by analogy, on the part of learners when faced with similar sets of forms.

(3) **Effects of stored root**

Irregularity is a property of stored roots, not words (which can be derived from roots by
rules). Since irregulars are stored as roots, they can be the ‘input’ to the word formation process. Moreover, only if the root is in head position can its irregularity be inherited by the word as a whole. A number of studies provide sufficient evidence for this assumption. The key concept that underlies this assumption is proposed by Kiparsky (1982b) who points out that irregular plurals generally can be contained in compounds as non-head elements. This is, however, not possible for regular plurals. This indicates that only irregulars but not regulars are stored words (but see Pinker and Prince 1994:331-333). In contrast, regulars are the products of rules and have to be the ‘output’ of the compound formation. The simplified schema for the organization of morphology below from Pinker (1999:180-183) illustrates this operation.

The first box, the memorized roots including irregular inflections (e.g. *mice* as well as *mouse*), provides the input to the second box where derivatives and compounds (e.g. *mice-infested*) are formed. However, a regular noun like *rat* cannot appear as *rats-infested* because the word *rats* must be formed by the inflectional rule in the third box, after the process of compounding, hence, it should not be available to compounding process. This is why we have *rat-infested*. This principle - what Pinker (1999:153) calls the ‘word structure theory’ - of word-based generative morphology has been developed by Kiparsky (1982a, b), Williams (1981a), Lieber (1980, 1992), Selkirk
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(1982), Pinker and Prince (1988), Kim et al. (1994), and Marcus et al. (1995). This is the basic insight of level-ordered morphology in which the derivational and inflectional processes can be organized in a series of levels (first box: level 1, second box: level 2, and so on), and this defines the possible ordering of morphological processes in word formation. Alegre and Gordon (1996) report that preschoolers are sensitive to this constraint when asked to form compounds like X-eater (green spiders eater = ‘an eater of green spiders’). The regular forms are typically stored morphemes (e.g. {walk}) available for ‘on-line’ composition. The irregulars, on the other hand, refer to the ones that are not available in such a way.

Finally, Table 3 below cited from Marcus et al. (1995:207) presents a list of circumstances in which irregular inflection applies.

Table 3.
“Novel circumstances in which irregular inflection applies”
(Marcus et al. 1995:207)

<table>
<thead>
<tr>
<th>Root in head position</th>
<th>Irregular-sounding words</th>
<th>Prefixed verbs</th>
<th>Endocentric compounds</th>
<th>Metaphors</th>
<th>Light verbs</th>
<th>Lexical compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Simple root</td>
<td>Irregular-sounding words</td>
<td>out-sang, re-broke</td>
<td>sawteeth, workmen</td>
<td>{chess} men,</td>
<td>blew him off, took a leak</td>
<td>mice-infested, teethmarks</td>
</tr>
<tr>
<td>2. Head of derived word</td>
<td>Irregular-sounding words</td>
<td></td>
<td>sawteeth, workmen</td>
<td>(intellectual) children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Head of compound</td>
<td>Irregular-sounding words</td>
<td></td>
<td>sawteeth, workmen</td>
<td>(intellectual) children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Semantic extension</td>
<td>Irregular-sounding words</td>
<td></td>
<td>sawteeth, workmen</td>
<td>(intellectual) children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Idiom</td>
<td>Irregular-sounding words</td>
<td></td>
<td>sawteeth, workmen</td>
<td>(intellectual) children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Combinations of stems</td>
<td>Irregular-sounding words</td>
<td></td>
<td>sawteeth, workmen</td>
<td>(intellectual) children</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.7. "Overgeneralization"

Overregularization refers to forms like *breaked and *foots in which the regular pattern is extended to an irregular stem. Another type of error such as *snoze for snoozed and *sheeps for sheep are called overirregularization. Together, these are known as overgeneralization. Overgeneralization by children is one of the subjects of longest tradition of documentation and research in the study of language acquisition and development (see for example, Brown 1973; Bybee and Slobin 1982). Since the arrival of the connectionist single-mechanism theory in the late 80's, it has become a famous battleground for so-called "the rule debate" between the single-system and dual-system theories. The subject is of paramount importance for both theories for two main reasons. One is because the well-established assumption of a symbolic rule system has been put in doubt. It is no longer universally accepted as being adequate to explain the deceptively simple phenomenon of past tense verbs in English, overgeneralization and its interesting development pattern. This is known as the U-shaped development. For DMT, the overall pattern is best-explained by the dual system, but only with an additional hypothesis about the crucial interaction between the two. The connectionists counter-claim that the same phenomenon can be achieved without them.

The most valuable achievement by the proponents of DMT is undoubtedly the unprecedented extensive quantitative study of the U-shaped development in the acquisition of English past tense (Marcus et al. 1992). The curve comprises the following three phases (121):
(121) Stages of U-shaped development in the English past tense verb inflection:

(1) early period of correct usage of both regular and irregular forms (e.g. sang, went, heard, etc.),

(2) followed by a period of overgeneralization of irregular forms (e.g. *singed, *goed, *hearded, etc.),

(3) followed by correct usage of regular and irregular forms (e.g. sang, went, heard, etc.)

The three stages make up a U-shaped curve of development (increase) and cessation (decrease) of errors, which can be interpreted as the manifestation of different mechanisms. DMT explains the phenomenon as follows:

Stage (1) is characterized by rote-learning. Children use correct regular past forms in past tense contexts (e.g. walked). Occasionally, they leave some regular verbs unmarked for tense, as in Yesterday we walk – (Cazden 1968 reported in Marcus et al. 1992). During this earliest stage, children have no choice but to memorize regular forms (which is one of the circumstances where 'regulars' are stored in memory). As for irregulars, children younger than 2½ use correct irregular forms (e.g. sang) in past tense contexts 74% of the time, and produced a bare stem (e.g. sing) 26% of the time. (Marcus et al. 1992, Marcus, Pinker and Larkey 1995, in Pinker 1999). This error is assumed to come from their weak memory trace for, and unreliable retrieval of, sang.

The induction of a rule is assumed to give rise to stage (2) which begins sometime between the end of the second year and the end of the third year. This is when overgeneralization errors of irregular verbs (e.g. *singed) appear at a rate of 2% along
with errors of omission (e.g. *sing) at a rate of 9%. This tandem development of walked and *singed can be interpreted as the result of a single underlying process: the "add -ed" rule. Here, errors of commission (e.g. *singed) is driving out those of omission (e.g. sing) down from 26% to 9%, and correct forms are increased from 74% to 89%. This stage – with the low rate of overgeneralization errors – continues well into the school-age years. Children's overregularization is not confined to irregular stems. They are also observed in irregular past forms (e.g. *broked, *ated) and neologisms (e.g. poonked). The traditional rule-&-rote analysis attributes overregularization to the sudden appearance of the rule. However, DMT points out that this is insufficient for the following reasons. The traditional analysis fails to tell the difference between the rule-possessing children and the rule-possessing adults. They ask: if they posses the same rule, why do children say *singed, when adults do not? To be more precise, why does the child, who said sang correctly earlier, err on the same verb and say *singed later? According to DMT, there is a difference between the productive application of the rule to a novel form (e.g. rick → ricked) and overregularization (e.g. sang → singed). The reason why the adults do not say *singed is not that because *singed has never been heard, but it is rather that its irregular counterpart sang has been heard. Then, why children say *singed? DMT credits this type of overregularization with the blocking principle and children's 'immature, fallible memory'. Their lexical entries for irregular verbs are not yet fully established, and are occasionally unable to retrieve the correct irregular form from memory and have no choice but to apply the regular inflection instead, resulting in overregularization errors. This is what crucially separates children from adults. Retrieval of an irregular form from memory is known to repress or 'block' the application of the regular rule. This interaction between regular and irregular, or the
link between the lexicon and rule, is called the blocking principle. Blocking is assumed to be a kind of ‘built-in’ component of the human linguistic apparatus, and hence innate. Thus, the proponents of DMT argue that the regular rule is applied by default to any form that does not have an irregular congener already stored in memory. As mentioned earlier, the associative memory favours frequency and similarity. In other words, irregular forms need similar irregulars to enhance association and retention. This explains why children tend to overregularize lower-frequency irregular verbs. The longer the child lives, the more reliable memory and retrieval become. Of course, occasional blocking failure is not always confined to children. When an irregular memory entry is weak, adults do overregularize (Ullman and Pinker 1990 in Pinker 1999), and this is thought to be diachronically responsible for permanent regularization of certain less-frequent irregulars observed in a language (equally, analogical irregularization can add new irregulars to a language).

By stage (3) and onwards, children achieve adult-like performance: improved memory, ability to retrieve irregulars reliably, reinstating the irregular status of the exceptions. This explains why errors like *singed go back to the correct forms again.

The DMT account not only provides support for the categorical regular-irregular distinction, but also offers a vital insight into the interaction of the two types of mechanism (and two types of forms: analogy-based and rule-based) that accords well with the data observed in the overgeneralization and U-shaped curve. It is the principle that “a successful retrieval of an irregular form in memory blocks application of the rule” based on the fundamental view: the mind of a child and the mind of an adult work the same way.
5.8. Rule, Regular and Default

DMT claims that mental rules are indispensable for knowledge of language. This position has been supported and defended by rigorous arguments and ample evidence (Pinker and Prince 1988, 1994; Prasada and Pinker 1993; Marcus 1995; Marcus et al. 1992; Marcus et al. 1995; Clahsen et al. 1992; Kim et al. 1994, Xu and Pinker 1995; Pinker 1999). Rules are productive, predictable, symbol-concatenating, memory-independent mental operations essential to human language processing system.

To take the English case, it operates with abstract categories (e.g. symbol "stem" or "verb"), hence equally and freely extends to novel verb stems, regardless of their phonological properties (e.g. wug → wugs, rick → ricked), it does not depend on frequency or similarity (about 15% of verbs are regular in parental speech; Marcus et al. 1992:75), or large class size (Clahsen and Rothweiler 1993). These properties of rules and rule-generated derivatives and inflections, according to Pinker and Prince (1994), are widely seen across languages. As Marcus et al. (1992) put it: "This hypothesis is about a kind of mental machinery available to all language learners but put to use in different ways in different language systems" (p.132).

Experimental results from a number of PDP models have questioned this view (Rumelhart and McClelland 1986; MacWhinney and Leinbach 1991; Plunkett and Marchman 1991, 1993; Seidenberg 1992; Daugherty and Seidenberg 1994; Hare, Elman and Daugherty 1995). Consistently present in their arguments is a suspicion that the dichotomy seems to stem from facts about the language rather than those about the language users. That is, the rule-like behaviour is nothing more than a description of the
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English inflection system, namely the proportional distribution of regular and irregular past tenses. For example, Rumelhart and McClelland argue that a sudden influx of regular verbs as a part of the child’s vocabulary growth causes the emergence of overregularization errors (see also Marchman and Bates 1994). However, Pinker (1999) confirmed that the proportion of regular verbs in parental speech remains constantly low – about 25 to 30% - between the age of two and five. The English plurals, for example, show dissimilar statistics, yet we observe the same U-shaped development with plurals as with past tense. Furthermore, a growth spurt in children’s vocabulary normally comes around a year or so earlier – mid-to-late ones – than the emergence of errors in the mid-to-late twos. Pinker concludes that language acquisition is a robust process; it is achieved despite a wide range of input mixtures across languages and cultures, and cannot be determined just by the nuances of parental speech statistics.

This clearly illustrates the two widely different views of the notion of rules which are often easily confused. Perhaps the connectionist’s view represents one of the traditional understandings of so-called linguistic rules. For the proponents of DMT, however, this is the biggest misunderstanding. According to DMT, a rule is to mean a psychological rule; hence, it does not have to be statistically general. Equally, a regular rule is “freely generalizable” in the psychological sense, and must not be mistaken with “majority pattern” in the statistical sense (Marcus et al. 1995, p.216-7). This linguistic/psychological distinction of the notion of rules has been strongly maintained and emphasized repeatedly in DMT. As Pinker (1999) claims, it is crucial to distinguish two very different senses of the notion rule and its related concept regular:
"Regular almost always is equated with the pattern followed by a majority of words in a language, or with the pattern adopted by newly coined words. But I have been using it in a different sense, one that pertains to the mental processes of speakers rather than to numbers and citations in a dictionary. "Regular" here refers to a rule that speakers treat as the default: an inflectional pattern they can apply to any word in a category, even if the word has never been stored with that pattern, or with any pattern, in memory. According to this theory, a regular pattern could, in principle, apply to a minority of words in a language, with the majority having to be learned one by one.

And the rule could fail to apply to a new word if the word is so similar to irregular words in memory that analogy is irresistible (as in to spling, which most people inflect as splang or splung). The only way to know whether an inflection is regular in the psychological sense is to see whether people apply it when their memory is blocked: when the word is new, rare, unusual, foreign, rootless, or headless."

(Iitals original; Pinker 1999:214)

So, the mere existence of common patterns or productive generalization to novel forms does not distinguish regular inflections from irregulars (because irregulars do display both). The important claim here is that real rules do not require access to memorized forms or their sound patterns, but applies as the default whenever memory access is not possible. In other words, a rule is psychologically real and regular only when it manifests itself in a situation where analogies fail. It must be a kind of generalization that is independent from analogies to stored patterns. Marcus et al. (1995) list 21 of such "circumstances in which memory patterns are not accessed and regular inflection is applied" (p.197). This is shown in Table 4.
Table 4.
“Circumstances in which memory patterns are not accessed and regular inflection is applied”
(Marcus et al. 1995:197)

<table>
<thead>
<tr>
<th>Circumstance Kind of word</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of entry or similar entries in memory</td>
<td></td>
</tr>
<tr>
<td>1. No root entry</td>
<td>Novel words</td>
</tr>
<tr>
<td>2. Weak entry</td>
<td>Low-frequency words</td>
</tr>
<tr>
<td>3. No similar entries</td>
<td>Unusual-sounding words</td>
</tr>
<tr>
<td>Competing entries or similar entries in memory</td>
<td></td>
</tr>
<tr>
<td>4. Competing root entry</td>
<td>Homophones</td>
</tr>
<tr>
<td>5. Competing similar root entries</td>
<td>Rhymes</td>
</tr>
</tbody>
</table>

Entry is not a canonical root

| 6. Rendering of sound      | Onomatopoeia                 | dinged, peeped              |
| 7. Mention versus use      | Quotations                   | “man”’s, “woman”’s          |
| 8. Opaque name             | Surnames                     | the Childs, the Manns       |
| 9. Foreign language        | Unassimilated borrowings     | latkes, cappucinos          |
| 10. Distortion of root     | Truncations                  | synched, man’s             |
| 11. Artificial             | Acronyms                     | PACs, OXes                  |

Root cannot be marked for inflectional feature

<table>
<thead>
<tr>
<th>12. Derivation from different category</th>
<th>Denominal verbs</th>
<th>high-sticked, spitted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>De-adjectival verbs</td>
<td>righted</td>
</tr>
<tr>
<td></td>
<td>Nominalizations</td>
<td>ifs, and, buts; loafs</td>
</tr>
</tbody>
</table>

Features cannot percolate from root to whole word (exocentrism or headlessness)

<table>
<thead>
<tr>
<th>13. Derivation via different category</th>
<th>Denominal nominalized verbs</th>
<th>flied out, costed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>14. Derivation via name</th>
<th>Eponyms</th>
<th>Mickey Mouses, Batmans</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Referent different from root</td>
<td>Bahuvrihi compounds</td>
<td>saber-tooths, low-lifes</td>
</tr>
<tr>
<td></td>
<td>Pseudo-English</td>
<td>walkmans</td>
</tr>
<tr>
<td>16. Lexicalization of a phrase</td>
<td>Nominalized VPs</td>
<td>bag-a-leafs, shear-a-sheeps</td>
</tr>
</tbody>
</table>

Memory failure

| 17. Children                         | Overregularizations         | comed, breaked          |
| 18. Normal speech errors             | Overregularizations         | comed, breaked          |
| 19. Alzheimer’s Disease              | Overregularizations         | comed, breaked          |
| 20. Williams Syndrome                | Overregularizations         | comed, breaked          |
| 21. Anomic Aphasia                   | Overregularizations         | comed, breaked          |
Clearly, the notion of ‘rule’ and ‘regular’ in DMT term is psychologically and neurolinguistically-motivated, rather than linguistically. Then, it seems more relevant to adopt DMT’ s definition of ‘rule’ in order to sharpen our focus on the psychological investigation of rdk process to see whether it is handled by psychological rule or by associative memory, or by both.

It is understandable that such confusion often arises because regulars in English past tense happen to be rule-governed both descriptively and psychologically. The fact that the regular words constitute a large proportion of the vocabulary is the original reason why the -ed forms has come to be called “regulars” for English, but according to DMT this is not the reason why we observe the strong regular/irregular separation effect in the language. Despite this claim, there is a wide-held view that the English past tense inflection system is not the paradigmatic test case for the psychological reality of dual-system in morphological learning. For them, English is a special case among the world’s languages that have more elaborate inflection systems such as Romance languages. DMT may have to face a serious problem accounting for a non-English inflection system that displays a radically different distribution pattern, for example, a system that does not have any preeminent regular pattern, or have several competing patterns and not just one rule. Acknowledging this skepticism (“English inflection is probably not the fairest arena in which to test the psychological status of rules” – Marcus et al. 1995, p.192), a number of studies have been carried out to test DMT, particularly the type frequency hypothesis, in other languages. This is to investigate the claim that a regular rule in the psychological sense does not depend on frequency; a
pattern found in a minority of words could well be a regular rule. One of these studies is a well-reported case of German (Clahsen et al. 1992; Clahsen and Rothweiler 1993; Marcus et al. 1995; Clahsen 1996, 1999).

First, we will look at German participles. German verb inflections differ from their English counterparts in the balance of regular and irregular patterns. According to Pinker (1999), 86% of the 1000 commonest verbs in English are regular; in standard German, on the other hand, only 45%, a minority, are regarded as “regular” (p.217). It is a good test case to start with because it is not clear as to whether there is a so-called regular class in the sense of “majority pattern”. To simplify somewhat, there are three classes of verbs: ‘weak’, ‘strong’ and ‘mixed’. Two types of suffix -t or -n are attached to the participle forms of verbs. Examples from Marcus et al. (1995:217) are shown in (122).

(122) Modern Standard German verb ‘infinitive’–‘preterite’–‘participle’s

**Weak verbs:**

*kaufen – kaufte – gekauft*  ‘to buy’–‘bought’–‘(has) bought’

*diskutieren – diskutierte – diskutierte*  ‘to discuss’–‘discussed’–‘(has) discussed’

**Strong verbs:**

*gehen – ging – gegangen*  ‘to go’–‘went’–‘(has) gone’

*vertreiben – vertrieb – vertrieben*  ‘to expel’–‘expelled’–‘(has) expelled’

**Mixed verbs:**

*rennen – rannte – gerannt*  ‘to run’–‘ran’–‘(has) run’

*bringen – brachte – gebracht*  ‘to bring’–‘brought’–‘(has) brought’

Descriptively, the weak German verbs can be considered as “regulars” because their
behaviour is perfectly predictable from adding -t. Both strong and mixed verbs belong to the “irregular” category since they undergo unpredictable phonological changes of stems, but not entirely arbitrarily. Notice the stem-past similarities and pair-pair similarities. The strong verbs are “irregulars” because stems usually undergo unpredictable changes, and they take -n ending instead of -t. The small class of mixed verbs is also referred to as irregulars but takes -t suffix like weak verbs.

Studies by Clahsen et al. (1992), Clahsen (1996) and Marcus et al. (1995) suggest that -t is treated as a default despite its low frequency. They have demonstrated convincingly by listing nine pieces of evidence to support their argument, most of which are among the 21 circumstances enumerated by Marcus et al. (1995). For example, German speakers applied -t to rare verbs, novel verbs, unusual-sounding verbs, irregular homophones, onomatopoeia, derivations from other categories, compounds, and so on. However, notice that this case suffers from the same drawback as English. The criticism is that from the outset it is descriptively similar to English regular/irregular differences in that -t is the only truly productive inflection that applies to all stems without phonological restriction, and the rest are not as frequent and productive as -t suffixation. What we really need is a case where more than one “regular” candidate competes for a default status.

The German plural makes a better test case because no single form applies to a particularly large proportion of nouns. German marks plural by one of five suffixes: -n, -er, -s, -e, -0 (no suffix). The perfect specimen for the test is the ‘-s’ suffix in that there is enough systematic parallelism between English -s except its rarity in type and token frequency. The -s suffix is called Notpluralendung “emergency plural ending” because it is used in cases like novel nouns, unusual-sounding words, borrowings, names,
onomatopoeia, and other noncanonical roots, those that are exactly the circumstances in which the default *-ed* applies in English (cf. Table 4). The most common plural is *-en*. In contrast, the *-s* suffix is undoubtedly the least frequent. Only a tiny proportion of nouns take *-s* ending as in *auto-s* (‘cars’) and *sozi-s* (‘socialists’). That is, 1% among 200 commonest nouns, and 4% among 25000 nouns in the largest database (Pinker 1999:222) in contrast with English counterpart of 98%. Three of the endings: *-e*, *-er*, and *-0* often trigger certain vowel changes in the stem known as “umlaut”. Which suffix is used depends partly on gender and morphophonology of the stem, yet it is virtually unpredictable and ungeneralizable. The *-s* suffix is the only plural that can occur without any morphophonological restrictions. Marcus *et al.* (1995) tested 48 adult German speakers on their ratings of three types of novel nouns: roots, names and borrowings, and have found that German speakers generalize the *-s* plural and the irregular plural forms in different ways, and concluded that in German default plural affix is *-s*, despite its low frequency. However, the experimental results on children’s overgeneralization of German plural by Clahsen *et al.* (1992) and Köpcke (1998) are more controversial. The children overgeneralize all the endings, and the most overgeneralized ending is the highly frequent *-n*, not *-s*. Marcus *et al.* (1995), based on the findings by Clahsen *et al.* (1992) and Clahsen *et al.* (1994), speculate that children “temporarily misinterpreted *-n* as a default”.

The German research seems to provide support for the frequency hypothesis. Nevertheless, the default status of the plural marker remains inconclusive. Probably one of the most ideal test cases is the acquisition of Polish genitive nominal singular inflections by Dąbrowska (2001). It is a highly complex and irregular system, and is marked by three endings *-a*, *-u* and *-y(i)* depending on gender. The singular endings are
shown below in (123).

(123) Polish Genitive singular inflections (based on Dąbrowska 2001:558)

<table>
<thead>
<tr>
<th></th>
<th>Masculine</th>
<th>Feminine</th>
<th>Neuter</th>
<th>Adjectival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singular</td>
<td>-a, -u</td>
<td>-i/-y</td>
<td>-a</td>
<td>-ego, -ej</td>
</tr>
</tbody>
</table>

Inanimate masculine nouns take either -a or -u depending on the noun, but the choice is largely arbitrary. Although there are broad semantic, morphological and phonological criteria (e.g. the -a ending is used for tools, body parts, native place names, most diminutives ending in -ek, -ik, -yk affixes, and nouns ending in a palatalized consonant; while the -u ending is for abstract nouns, collective nouns, borrowings, nouns ending in derivational affix -unek), there are many exceptions. In addition, some nouns such as borrowings do not decline at all. Since -a is the more frequent ending (both type and token frequency of 70-80% of the masculine nouns), it is usually considered as “regular”. Dąbrowska gives the distribution of -a and -u endings in 15 contexts (pp560-1) calling for a default inflection, the Polish equivalent of Table 4. Unlike English, most of the cases can take both -a and -u; three of them can or must be left uninflected (Ø), and two cases take the adjectival ending -ego. Then, this makes a good test case since both -a and -u use the same morphological mechanism, namely suffixation, can be suffixed to an open-ended class of nouns, and are fairly unrestricted phonologically. There are additional -ego and Ø to make the situation more competitive. The DMT predictions are that (a) children should make relatively frequent overgeneralization errors, and (b) they should consistently overgeneralize one of the
endings. The results (based on spontaneous speech by three children over a number of years) provide no evidence that children treated any one particular ending as a default ending. It has been found that (1) overgeneralization errors appear late and are very rare, (2) the inflection has been acquired early and almost without error, (3) all three endings are overgeneralized, (4) the \(-a\) ending was overgeneralized more frequently than \(-u\), and this coincides with the statistical frequency distribution. This parallels the German plural case in which the most frequently overgeneralized ending is not the 'emergency -s', but \(-n\) with the highest type frequency. Therefore, Dąbrowska speculates that the children seem to acquire the three productive inflections using associative memory alone, concluding that the sharp contrast between a fully productive default inflection and memory-based irregular patterns may not always be cross-linguistically viable.

Similar conclusion has been drawn by Bybee 1995a, Orsolini et al. (1998), Baayen et al. (1995) (in Orsolini et al. 1998), Ragnarsdottir et al. (1996) (in Orsolini et al. 1998) and Köpcke (1998). Pinker (1984) claims that children naturally and actively seek for default, but some other studies seem to suggest that this is not always the case.

5.9. How is a “regular rule” learned?

“How does a learner decide to internalize a certain pattern as a regular rule or list of stored items?” This is one of the most challenging questions for all cognitive theories. The emergence of rules, according to one hypothesis, is controlled by maturational factors (Pinker 1999:203). However, recognition/extraction of the affixation pattern itself is one thing (which can be achieved well by associative memory alone, and this is
what connectionists claim), and assigning it with regular (default) rule status is quite another. Recall that regular forms do not depend on token frequency and similarity. Recall also from the previous section that a regular rule does not have to depend on their type frequency and applicability. Marcus et al. (1992:133-7) considers several logical possibilities as to which ‘cues’ children use to acquire a regular rule (124).

(124) Cues children can use to determine a certain pattern as a regular rule

(1) “First, Pinker and Prince (1988) suggested that the crucial cue might be the ability of a morphological process to apply successfully to several kinds of stem, each belonging to a different competing irregular pattern. For example, need-needed exists despite bleed-bled and feed-fed; blink-blinked exists despite drink-drank and sink-sank; seep-seeped exists despite sleep-slept and sweep-swept.”

(2) “Second, the mere heterogeneity of the stem patterns that are heard to be regularly inflected (regardless of whether the inflection trumps some competing irregular pattern characteristic of such stems) may tell the child that the inflection is the product of a rule with either well-defined conditions or none at all.”

(3) “Third, a very reliable cue for regularity is the ability of a process to apply to verbs that are derived from other categories such as nouns, adjectives, and names. These verbs do not have verb roots and hence have no base lexical entry to which an irregular memorized form can be attached; only a fully general regular rule can apply to them, acting as a default.”

(4) “Fourth, even a single word with a highly unusual sound pattern, such as out-Gorbachev’d or rhumba’d, provides information about the generality and possible default status of a morphological pattern.”

(5) “Fifth, the syntactic requirement that tense be marked obligatorily may impel the child’s learning mechanism to seek a pattern that can provide the needed form under a wide range of circumstances.”

(6) “Finally, aspects of the phonological properties of regular inflection might provide cues about regularity. For example, the English past tense inflectional process consists of a suffixation, which is the same kind of process used for
the third person singular inflection (-s), the progressive inflection (-ing), the plural, and the possessive. This could signal to the learner that, in English, suffixation is the process used quite generally for regular inflection whereas the mutations seen in irregular verbs do not belong to any larger system (see Wurzel, 1989).”

(Italics original; Marcus et al. 1992:133-5)

These are all ‘hypothetical’ cues logically available to the learner in the acquisition of inflectional process. Then, in order to cater for different rule types and processes across different languages, the principles underlying these cues help decide what does and does not constitute a cue relevant to one’s situation. Only then, one can speculate which of such cues are available in child’s environment, reliable in signaling a default process, and actually used by the child in his/her learning mechanism.

5.10. Psycholinguistic Issues on Compounds

There is a substantial amount of experimental literature on production, perception and acquisition of morphologically-complex words. Among them, the study of the mental lexicon has occupied the central area of psycholinguistic research comprising several branches such as morphological access, processing and representation. The much-debated yet inconclusive issue is on the type of morphological information coded and stored in the lexicon. Studies on compounds in these areas have received much less interest compared to inflected and other derived formations. In the following sections, we focus on some of the issues and findings regarding how compound words are treated
by the learner. This includes how compounds can be processed and represented in the mental lexicon, which is directly relevant to the earlier hypothesis of the pseudo-rdk phenomenon (4.4.4.4.), and how they are learned, which has an important implication for the timing of the rdk acquisition model.

First we look at the issue of mental representation of compounds. There has been a very popular and well-researched area in the study of word recognition that concerns morphological decomposition. It addresses the question of how morphologically-complex words are represented in the mental lexicon: whether they have a representation of their own or are represented at the lexical entry for their stem. There are two major conflicting hypotheses: full-listing and morphemic, each claiming a different unit of representation. The full-listing 'non-decompositional' hypothesis (e.g. Butterworth 1983, Dell and O'Seaghdha 1991) suggests that a lexical storage and access unit is the whole word representation, irrespective of whether the word is monomorphemic or polymorphemic, and that each morphologically complex word has its own entry in the mental lexicon. In contrast, the morphemic hypothesis (e.g. Taft and Forster 1976; Taft 1979, 1981, 1988, 1994) – also known as “affix stripping” or “parsed” model – proposes that complex words are decomposed into their constituent morphemes prior to lexical access which segments a polymorphemic string into single roots and affixes; this occurs automatically and indiscriminately; hence, the mental lexicon contains only monomorphemic entries and polymorphemic words are accessed through their root morphemes, either free (e.g. {happy}) or bound (e.g. {-ceive} in receive) (Libben 1994:370). Both hypotheses are well-supported in both the psycholinguistic and neurolinguistic literature, and the discussion seems far from conclusive. Furthermore, between these extreme theories there are proponents of mixed
theories that allow both prelexical decomposition and whole word access — known as a dual-listing model — including Augmented Addressed Morphology Model (Caramazza et al. 1988), Morphological Race Model (Frauenfelder and Schreuder 1992) and connectionist network (Stemberger and MacWhinney 1986; Seidenberg and McClelland 1989).

Some evidence shows that derived words in general are processed differently from inflected formations based on the information such as linearity (i.e. the temporal order of information) and word-internal structure (e.g. Taft and Forster 1976; Libben 1994; Järvikivi and Niemi, 1999). Recent evidence seems be in support of a modified morphemic model that rules out obligatory and automatic prelexical decomposition; multimorphemic structures can be accessed and stored ‘optionally’. Morphologically-complex words are stored in terms of morphemes except that very common morphologically complex words and frequent lexemes may be stored as (consciously unanalyzed) wholes, even if they are morphologically analyzable (Stemberger and MacWhinney 1986; Bybee 1995b; Baayen, Lieber and Schreuder 1997; Waksler 1999, but see Hay 2001). More transparent derivatives tend to be stored morphemically i.e. analyzed form (Bauer 2001:109). Smith and Sterling (1982) report that transparency is a predictive variable for subject’s judgments on the morphological complexity of prefixed words. Baayen and Neijt (1997) and Baayen, Burani and Schreuder (1996) provide a counterexample to the claim by Anshen and Aronoff (1997) that words falling into productive morphological categories are not stored in the mental lexicon, and argue that high-frequency regular derivatives can be stored when it involves concept formation and lexical specialization.

As for compounds, evidence suggest that transparency as well as productivity
may be the factors determining whether morphologically complex forms are decomposed in the processing system (e.g. Libben 1998). In addition, acquisition research suggests that children are attentive to the transparency and simplicity of the elements they use in compound formation (Clark 1998). Productivity (see 2.4) in the current context largely corresponds to what DMT refers to as the productive regular inflection. As Alegre and Gordon (1999) point out, “many psycholinguistic studies have equated the status of derivational affixes with regular inflectional affixes in that both are said to involve morphological decomposition for lexical access. This contrasts with irregular inflections, which are found to be stored as whole words” (p.348). Semantic transparency refers to the situation in which the meaning of a compound is synchronically related to the meanings of its constituents (e.g. beanpole). A complex word is transparent when children know the meanings of its elements (roots and affixes). When children coin new words, one factor that affects the forms they choose is transparency. Semantic opacity refers to the situation in which the relation between the meaning of the whole compound and (one of) its composite words is not apparent or is lost etymologically. Thus, their meanings cannot be derived from the meanings of their constituents synchronically. In the psycholinguistic literature, compounds are often classified as fully transparent, partially opaque or truly opaque. Compounds can be truly opaque when there is no semantic relation with any constituent (e.g. blackguard), or partially opaque when a semantic relationship with one constituent exists (e.g. jailbird). Simplicity of form in compounds, according to Clark (1993), is another key factor in morphological production and perception. A word is simple when the elements to be combined require either no changes (or minimal changes) in form. In a language in which modifier-head ordering in compounds is consistent with other constructions, it
should be easier for the learner to master compounds than a language in which it is not.

For example, Andrews (1986) report greater effects of decomposition for compounds than for affixed words, and concludes that compounds are 'optionally' accessed through their constituents. Sandra (1990) and Smith and Sterling (1982) independently propose that the semantic transparency of a multimorphemic string is related to whether they are decomposed. Sandra suggests that opaque compounds (e.g. *buttercup*) and pseudo-compounds (e.g. *boycott*) have their own independent lexical representation, and that there is no analysis into morphemes in such cases, though there is in the case of transparent compounds. Sandra thus concludes that transparent compounds may have no representations in the lexicon because their meaning can be determined each time anew from the constituent meaning. Zwitserlood (1994) also suggests that even partly opaque compounds are stored lexically as a function of their elements, but that opaque compounds have a listed semantic representation separate from that of the elements involved.

5.11. Acquisition of compounds

Clark and Hecht (1982) found that noun ‘root’ compounds were the earliest derivational construction to be productively mastered. They list three main principles underlying the acquisition of derivatives. Derwing and Baker (1986:331-2) summarize as follows:

1. a principle of *semantic transparency*, based on the early suggestions of Slobin (1973), which implies both that the child will prefer familiar forms to unfamiliar forms in constructing new combinations (hence compounds
precede the innovative use of the bound suffix -er, and that each new form is first used with only one (consistent) meaning – in this case ‘agent’ alone, rather than both ‘agent’ and ‘instrument’

2) a principle of productivity, based on much the same notion of (pattern) frequency or ‘rule strength’ outlined in Derwing and Baker (1979a), which strongly influences the choice of which construction or meaning is acquired first

3) a principle of conventionality, which essentially serves to give a name to the still largely mysterious process by which the child eventually abandons his own innovative forms (e.g. build-man, blow-machine, ‘Don’t broom my mess’) in favour of those forms conventionally used by other members of his speech community to convey the same intended meaning (e.g. builder, blower, and the verb sweep).

(Clark and Hecht 1982 in Derwing and Baker 1986:331-2)

There is plenty of other evidence that compounding is very easily accessible and acquired very early, particularly in languages which use it widely and productively (as young as 1½). Clark and Hecht (1982) report that the earliest agentive nouns coined in English tend to be noun compounds, and tend to yield later to standard derivatives (e.g. build-man for builder). Derwing (1976) and Derwing and Baker (1979) investigated the English-speaking child’s learning of six derivational constructions (i.e. -er ‘agentive’ and ‘instrumental’ nominals, -ly adverbs, -y adjectives, the -ie ‘affectionate-diminutive’, noun compounds) show that the noun compound was found first to be productively employed by a substantial portion of preschool children. All of the constructions showed a steady, positive developmental trend up through the adolescent period, and were productive for the majority of both the adolescent and adult subjects groups. Clark (1993) reports for one English-speaking child that all of his innovative words were compounds before age 2; between age 2 and 5 some 70% were compounds. Her studies on Dutch, German and Swedish-speaking children also provide similar figures. Shirose
and Kiritani (2001) observe in their acquisition study of the compound accentuation rule in Tokyo Japanese that 50% of 3 year-olds, 70% of 4 year-olds and 84% of 5 year-olds are capable of producing novel nominal root compounds (i.e. [noun root + noun root]). Furthermore, by age 2 - 2½, according to Clark (1998), children seem to have learnt to identify the modifier and head in such root compounds.

On the other hand, the figures are considerably lower for languages where compounding is not particularly productive. Clark (1993) reports that children acquiring Romance languages produce virtually no root compounds until around age five or later. As for production of new derivatives, as often conflicting pieces of evidence suggest, it might be fair to say that real speakers do not always seem to find it as easy and automatic as they appear to find the production of new inflectional forms. Some argue that derivation is, in some sense, 'hard' for speakers to do; Bauer (1997) reports that children in early teenage years have not fully acquired the ability to make new words according to community norms. In contrast, for others, as has been mentioned above (e.g. Clark and Hecht 1982), some derivations, in Hungarian for example, appear to be produced as early as eight months (MacWhinney 1976) and as automatically as inflectional morphology. It should be also noted that individual speakers of a particular language probably do not internalize their morphemic knowledge in the same way (Smith 1995).
5.12. Acquisition of Alternation

There is a widely held view in child phonological acquisition that morphophonemic acquisition, such as alternation, happens relatively late. Unfortunately, however, there is little cross-linguistic evidence as to exactly when children come to possess full, active command over alternation. What most studies suggest is that there are wide variations among children across different processes in a fairly long time span. To take English as an example, Smith (1973) found that his son Amahl at age of 2;2 has not yet established the systematic alternation pattern of plural suffix. Berko’s (1958) study show that the children, particularly four-year-olds, did not perform particularly well. The rate of regular past-tense forms given to Berko’s novel verbs was 51 %. Pinker (1999) reports that English children’s overregularization errors of irregular plurals emerge at around age of three and continues up to school-age years. One thing we can be certain is that the child has to have understood the forms and processes in question before they start using them. Then, we can only speculate that the relative timing of the acquisition of alternation in general is after the system of contrasts and phonotactics of the target language have been learned.
Chapter Six

HYPOTHESES

6.1. Introduction

This chapter aims to apply what we have seen so far to the case of rdk acquisition. The key predictions from the two theories are brought together in order to construct an integrated hypothetical rdk acquisition model. First, the biggest point of inquiry is addressed: “is rdk rule-based or memory-based?” The notion of ‘psychological rule’ holds the key to the reality of rdk in the speaker’s mind. It is suspected for a number of reasons that rdk may not necessarily be learned as a rule in DMT terms. Second, OT provides the up-to-date prototype acquisition model in the form of multi-staged developing grammars that predict expected and unexpected outputs for given inputs. Each stage is distinguished by its own ranking and outputs (e.g. LL-violating grammar) and the type of rdk knowledge (e.g. memory-based rdk). This is followed by the DMT accounts on how the learning of the rdk irregularity is achieved. By proposing “saliency” (Vance 1979) as a primary criterion for rote-learning, and the rdk irregularity
as the manifestation of the knowledge about the phonological conditions, the theory, in conjunction with the issues in morphological storage, proposes various learning patterns on how the conditions can be discovered and learned by the speakers of different ages.

Before going into a detailed discussion on the regular-irregular distinction in rdk, there is a point to be clarified. We have been concerned primarily with the concept of regularities and irregularities of various forms and processes, but in two different contexts. First, there is the most neutral sense of regular/irregular, from which the whole study sprang — namely, the fundamental irregularity of rdk: as an ‘irregular phenomenon’, not as a ‘process’, ‘paradigm’ or ‘form’. The phonological process itself, i.e., the morpho-phonological alternation and phonological change made, is systematic and perfectly regular in terms of the voicing configuration between input (underlying form) and output (surface form). In other words, at the phonological level, it displays regularity. The rdk phenomenon, on the other hand, is apparently irregular in the sense that the regular process is sometimes disrupted in an unsystematic manner. In short, the fundamental irregularity is the incidence of the phenomenon, not of the process itself. In this sense, the distinction is no different from that in English past tense inflection, for example.

In the psycholinguistic context, however, the regular/irregular contrast appeals to a psycholinguistic distinction: it comes to represent the two qualitative different human mechanisms of rule and associative memory. The distinction seems to differ from many properties of so-called ‘regular’ rules in traditional descriptive grammars. Under the current interpretation, the regular is to mean a frequency/similarity-independent, freely-generalizable mental rule operation that applies as a default, and irregular as a frequency/similarity-favouring operation based on associative memory. As we will see
in the following sections, the distinction will become rather complex when it is translated into the context of rdk, although it is vitally important.

6.2. Is rdk ‘rule-based’ or ‘memory-based’?

The question asks whether rdk is generated by rule or by memory. This is the biggest point of inquiry. The notion of memory-(in)dependency is particularly relevant to rdk because this is the only powerful criterion capable of categorizing the rdk process in psychological terms. As we have seen in the complex and irregular cases of German (Clahsen et al. 1992, Marcus et al. 1995; Köpcke 1998, Clahsen, 1999), Polish (Dąbrowska, 2001) and Italian (Orsoloni et al. 1998), as well as clearly productive cases of English (Berko 1958, among many others), the notion of default (in cases where several processes compete) or memory-independency has often been used as the vital evidence to show that a process under investigation is a psychologically real phenomenon.

One of the most powerful type of psycholinguistic evidence in support of the psychological value of rdk is to see whether rdk is applied productively to novel words. The current study is largely dedicated to an elicited production test involving invented nonsense words. Only the phonological conditions affecting rdk are incorporated into the stimuli mainly for practical reasons (see 7.1.).

Our prediction is that rdk may not be applied to nonsense words at all. The doubt has been underlined from the outset, and the fundamental irregularity has constantly been implied to be responsible for this. It is about time to justify this long-pending
doubt by listing a number of reasons why we suspect rdk receives a default status. We have seen in 5.9. that there are several possible cues available to children in acquiring a regular rule. However, compared to most of the known cases where ample evidence is available, the phenomenon seems to lack certain vital cues that mark it out as a rule process, or what cues there are may be too elusive to be useful.

First of all, rdk does not behave in a rule-like (i.e. exceptionless) way. This is very evident when compared not only with English verbal inflection, but with that in Japanese too. Of course, as Marcus et al. claim (1995:133), this is not a big problem as multiple rules may exist, some being sensitive to properties or subcategories of the morpheme to be compounded. Rdk may appear to display some properties which suggest the multiple rule solution: (a) it applies only to the second element of a compound, (b) it is subject to the general constraint of LL, (c) it is largely constrained to the Y vocabulary stratum, to name but a few. The problem for the theory is that some of the conditions on rdk are not at all well-defined. Consequently, as regards to (124-2) in 5.9., this obscures the contrast between the ‘heterogeneity’ of a class of stems that undergoes a default rule (e.g. ‘verb’) and the ‘homogeneity’ of a class of stems that does not (e.g. ‘verb stem of sCCV[η] type’ such as string). The Japanese child may detect the heterogeneity of stems that show rdk, but the lists of stems that do not show rdk seem equally heterogeneous. The poor contrast could discourage rather than encourage the child from treating the process as a rule.

Second, a process normally applied to foreign borrowings, neologisms, onomatopoeia, quotations, etc. is a reliable cue to signal a regular rule (e.g. Pinker 1999). Due to the stratum-specificity, however, rdk never prevails in foreign borrowings or onomatopoeia. Y neologisms are very rare. This partly reflects the current situation
where neologisms are predominantly non-Y. Among 177 so-called ‘newly coined words’ officially nominated between 1984 and 2002\textsuperscript{11}, there are only five Y compounds, all of which are newly compounded words involving existing words, i.e. home-gorosi (‘praise-murder’), syooyu-gao (‘soya-sauce-face’), zassoo-damasii (‘grass-spirit’), otona-gai (‘adult-buying’), geki-kara (‘super-spicy’), and four of them show rdk. The reason why -kara is not -gara in the last compound geki-kara is because it normally does not undergo rdk for unknown reason. All these examples demonstrate that (Y) compounding in Japanese is highly productive. However, note that none of the four rdk examples are a productive application of rdk to a completely new Y word. They only tell the learner how frequently these second elements show rdk in existing compounds, and crucially fails to answer the fundamental question of whether rdk is synchronically alive productive process.

Thirdly, rdk is not obligatory. Unlike the marking of the past tense which is a syntactic requirement and hence obligatory, the use of rdk compounds is hardly obligatory. This is not to be confused with the use of rdk voicing in compounds. For example, the use of ori-gami is always circumvented easily, even by a child before age of 3, by a phrase oru kami (‘paper for folding’ or ‘paper to fold’). Obligatoriness itself does not signal a rule, but non-obligatoriness may greatly reduce a chance of the most general process being promoted to a rule/default status. There is only one situation where one is made conscious about rdk applicability, and that is when one has to read family/place names. These are normally written in Chinese characters which give no indication of pronunciation and may in fact have alternative pronunciations, e.g. [taçima] and [taçima] for 田島.

The fourth reason is the way the rdk voicing is marked. The marking of past tense in English, for instance, nearly always has phonological consequences both for regular or irregular items. The regulars have the -ed suffix and the irregulars have their own vowel changes. Rdk, on the other hand, marks its regularity by the voicing alternations, yet its irregularity is left unmarked. In this respect, in theory, a child has a fair chance of 50/50 to set +rdk as a default, or -rdk as a default, which means in effect no default for rdk. Moreover, there is often no apparent and direct link between the absence of rdk and the properties of the compound member(s), whether phonological, syntactic or semantic. The learner has to actively look into thousands of second elements for clues as to why the voicing is absent (or present), which, as we know already, is a daunting task. Even to discover that rdk is blocked by various properties of the second elements, e.g. LL, (rather than the property of the process itself) requires quite an observation for a naïve learner.

Fifth, since the rdk voicing is the only device available to mark the difference in forms, this leads to a potentially confusing distinction in both form and concept between so-called regular and irregular. Up till now, the regular/irregular distinction in terminology and concept has been bluntly and deliberately used to describe the case of rdk, but it needs further clarification at this point. Of course, what is regular and irregular in rdk is the very question under investigation, and this is the only reason why the notion of default becomes most relevant. However, let us suppose for the moment that rdk is a regular rule, and a +rdk form is a regular form. An irregular form would be a -rdk form in which rdk is absent. To illustrate the confusion, consider an *overregular/irregular pair. An overregularized form is an error which receives incorrectly the regular or default pattern instead of the correct irregular counterpart,
which should block the regular process. So, for instance, we have the familiar *go-ed/went pair from English. In rdk a corresponding *overregular/irregular pair would be, say, *yaki-zoba/yaki-soba (‘fried noodles’) pair as well as *kutu-bimo/kutu-himo (‘shoelaces’) pair, which is one of the mysterious exceptions (along with a few other phonologically similar forms, collectively referred to as the +/h//m/ condition; see 3.3.5.). These pairs seem satisfactory because we are supposing that non-rdk forms like yaki-soba and kutu-himo correspond to so-called irregulars. Now, what about ori-gami/ori-kami (‘paper folding’) pair? Is origami an overregularized form? Of course, the answer is no. It is not an over-irregularized form either. The relationship here is regular/root pair which corresponds to what English walked is to walk rather than what *singed is to sang. The main source of confusion is that an ‘irregular’ form ([{-kami}]) and the canonical ‘root’ ({kami}) are phonetically identical. That is, the outputs in rdk lack a range of distinct irregular forms and properties corresponding to English sang, brought, forbore, etc. The result is the same even if we switch them around and posit ori-kami as regular and ori-gami as irregular. A yakisoba/yakizoba pair becomes an *overirregular/irregular pair, and so does the kutu-himo/kutu-bimo pair. For this reason, the term regular/irregular will be avoided in the context of rdk for the remainder of the study unless otherwise noted. As for the learner such unclear distinction in both forms and concept is certainly not a very useful cue for rule learning, in fact it may have the opposite effect.

Sixth, as will be discussed later in 6.3.1.1., the researcher’s own observations of questions such as “what -game (kame ‘turtle’) is this?” suggest that some speakers seem to have highly rdk-frequent second elements stored with the rdk [+voice] underlyingly. This is in a morphemic representation of {-game}, for example. This enables the
speaker to handle rdk quasi-productively in novel compound formation without internalizing rdk.

Finally, despite the claim that children naturally and actively seek for defaults (e.g., Pinker 1984; Marcus et al. 1995), some studies report little evidence that they always find one. Of course a process being irregular does not prevent learners from learning. In fact, plenty of evidence suggests children have little trouble learning. The point is that the learner can learn the process without a default. All of these problems point towards one question: why need rdk be a (default) rule?

There are a few factors that still allow rdk to be learned as a rule. One is that learning a rule does not depend on frequency (e.g. Prasada and Pinker 1993), and even if the token/type frequency of rdk compounds is very low, this will work in favour of rule learning. To give some idea on the type frequency of rdk, the researcher’s own dictionary count$^{12}$ of the number of rdk cases in 4230 nominal and verbal compounds of all lengths shows 74.34% +rdk rate (3144/4230). The token frequency of rdk words in ordinary conversation is believed not as high as say, verbs (but they are certainly heard from adults’ speech and seen – always written in kana forms – in books for readers as young as early preschool). Nevertheless, without reliable data on the frequency of rdk compounds in actual speech, this assumption is not firm. Secondly, certain compounds indicate rdk clearly. The RDPY (reduplicated Yamato compound) is made from reduplicating the same root but the second element with rdk as in kata-gata (‘everyone’; kata ‘person’) and toki-doki, (‘sometimes’; toki ‘time’). Another possibility is the strong claim that symbolic rule computation is indispensable, and we cannot deny the possibility that some learners may be more rule-orientated or rule-favouring than

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others that they somehow learned to handle the phenomenon in a way parallel to what
the dual-route theory claims. Finally, a series of informal interviews by the researcher
implies that people do seem to have different degrees of productivity\(^\text{13}\). The reactions
and responses tend to vary widely; some seem to have no idea what the experiment is
all about, some others insist there should be no rdk at all, yet a few do apply rdk to
nonsense words.

6.3. Acquisition of Rdk

The other key point of enquiry concerns how rdk is learned and developed. By using the
same test stimuli (invented nonsense words) with a range of native speakers including
children, it is possible to find out how rdk is learned as well as what is learned about rdk.
This section attempts to outline the hypothetical overall course of development in
reference to the developing grammar model with some predictions on the timing of
acquisition.

6.3.1. Stages of rdk development

From the outset, there is a fundamental theoretical difference in the way OT and RDT
(Rule-and-Derivation theory) account for the rdk process. The learning task in OT is

\(^{13}\) Vance's (1979) study provides little indication on this point since it was based on the alternative choice
task presented orthographically.
reduced to underlying forms and relevant constraint ranking, while that of RDT consists of underlying forms and the set of rules. We have seen that OT successfully reduces some of the language-specific conditions, such as LL, VOb+Ob and stratum-specificity to the ranking of universal constraints and their interactions. It was also emphasized previously that this fundamental OT principle has a significant implication on the acquisition model of rdk. Most importantly, since the constraints are universally given, they need not be learned. It is the ranking and reranking that have to be learnt. RDT claim otherwise: apart from the rdk rule, everything else has to be learnt. Inevitably, violation of LL is a natural outcome. As we will see, the two theories make different predictions on certain error patterns in the course of rdk acquisition.

The course of development is predicted to follow the developing grammar model constructed on the learnability principles in OT. The model, previously given as Table 2 (4.4.5.) is reproduced in (125).
Sequential changes of OT grammars and expected outputs for the given input types (symbol ‘∅’ indicates ill-formed rdk grammar and / erroneous output)

<table>
<thead>
<tr>
<th>Input type</th>
<th>(\mathcal{L}_0) ‘no voiced obstruent’</th>
<th>(\mathcal{L}_1) ‘no rdk’ (pseudo-rdk)</th>
<th>(\mathcal{L}_2^\text{(S)}) Strong UNIFORMITY [voice]</th>
<th>(\mathcal{L}_2^\text{(W)}) Weak UNIFORMITY [voice]</th>
<th>(\mathcal{L}_f) ‘full rdk’</th>
</tr>
</thead>
<tbody>
<tr>
<td>/hasi + hako/</td>
<td>[hasi-hako]</td>
<td>[hasi-hako]</td>
<td>[hasi-bako]</td>
<td>[hasi-bako]</td>
<td>[hasi-bako]</td>
</tr>
<tr>
<td>/ori + kami/</td>
<td>[ori-kami]</td>
<td>[ori-kami]</td>
<td>[ori-gami]</td>
<td>[ori-gami]</td>
<td>[ori-gami]</td>
</tr>
<tr>
<td>/yaki + soba/</td>
<td>[yaki-soba]</td>
<td>[yaki-soba]</td>
<td>[yaki-soba]</td>
<td>[yaki-zoba]</td>
<td>[yaki-soba]</td>
</tr>
<tr>
<td>/tabi + hito/</td>
<td>[tabi-hito]</td>
<td>[tabi-hito]</td>
<td>[tabi-hito]</td>
<td>[tabi-bito]</td>
<td>[tabi-bito]</td>
</tr>
<tr>
<td>/hana + gara/</td>
<td>[hana-kara]</td>
<td>[hana-gara]</td>
<td>[hana-gara]</td>
<td>[hana-gara]</td>
<td>[hana-gara]</td>
</tr>
<tr>
<td>/tabi + gara/</td>
<td>[tabi-kara]</td>
<td>[tabi-gara]</td>
<td>[tabi-gara]</td>
<td>[tabi-gara]</td>
<td>[tabi-gara]</td>
</tr>
</tbody>
</table>

After the earliest \(\mathcal{L}_0\) stage in which the voiced obstruents have been introduced to the inventory and the basic phonotactics have been learned, we have the following three stages that are directly relevant for our current interest:

1) No-rdk stage \(\mathcal{L}_1\) (i.e. lexically-generated rdk)

2) Intermediate stages \(\mathcal{L}_2\) (i.e. basic rdk with minor variations in ranking)

3) Full rdk stage \(\mathcal{L}_f\) (i.e. the full (target) rdk grammar)
6.3.1.1. No rdk ('Pseudo-rdk') stage: \( \mathcal{L}_1 \)

This is a stage prior to the acquisition of rdk as a default process where the child has no rdk producing grammar. The term ‘no rdk’ is to mean that the productive rdk competence is absent; this should not be confused with the absence of rdk utterances and rdk competence altogether. The pseudo-rdk phenomenon refers to the hypothesis that all rdk utterances during this stage are deceptively surface-true, but crucially, they are memory-driven opposed to genuinely rule-driven, hence, the name ‘pseudo-rdk’. This can be equated with the earliest stage when English children mark the tense correctly prior to the acquisition of -ed rule. Children produce rdk correctly, not by rule computation, but by memory. It obtains when the input to the grammar bears the rdk [voice] underlyingly, and it surfaces. First, there is a possibility of full-form representation. It is known that some opaque and partly opaque compounds are stored lexically (Stemberger and MacWhinney 1986; Sandra 1990, 1994; Zwitserlood 1994; Marslen-Wilson et al. 1994; Marslen-Wilson and Tyler 1997). So, semantically distinct and less transparent compound like ne-bumi ('valuation', cf. humi 'stamping') is probably stored as a whole {nebumi}. Some studies also suggest that very common, frequent and transparent morphologically complex words can have full-form representations, even fully regular inflections (Baayen, Burani and Schreuder 1997; Baayen and Neijt 1997). This implies that some highly frequent and transparent compounds, e.g. nitiyoo-bi ('Sunday'), might be stored as {nitiyoo\(\textbf{b}\)i} even though it is morphemically analyzable. Second, there is the morphemic representation particularly common with transparent compounds (Sandra 1990). The recognition of the rdk morpheme \( p \) must be initiated by processing and storing compounds in this way. We
now make a further prediction by positing a third form of representation: a rdk-specific bound morpheme. It is speculated that the second element in origami, for example, might have a representation \{-gami\} bearing underlying rdk [+voice] along with the root \{kami\} in the mental lexicon. This may be plausible with some highly rdk-frequent second elements like \{-game\} (‘turtle’) which serves as a handy input in coining new compounds, say kuro-game (‘black-turtle’), before having learned the rule. In fact, children and adults do ask things like kore nani-game? (‘this is what-turtle?’ = ‘what -game is it?’) by pointing at a turtle that looks familiar, but cannot remember what it is called. It is also reported by some parents of 3-4 year olds that their children spontaneously produced novel compounds like baka-bati (‘stupid-bee’, cf. hati ‘bee’) involving the highly rdk-frequent second element. If our prediction is correct, we expect that deceptively productive application of rdk is observed in real words that often occur in rdk forms in novel combinations, but crucially not in nonsense words.

This stage, by definition, should continue up to the time when the rdk rule is acquired and the relevant constraint ranking for productive rdk is triggered. The phenomenon itself, however, does not disappear there. Even when the rule has been acquired the productively computed rdk and memory-driven rdk can and should co-exist. If a learner does not learn rdk as a default, the knowledge of rdk for the learner will probably remain entirely lexical. When test stimuli include highly rdk-frequent real words along with nonsense words, we should be able to see how these two mechanisms work alongside each other.
6.3.1.2. Intermediate stage(s): $L_2 \otimes [S], L_2 \otimes [W]$

These stages begin with a critical period when the phonological regularity is discovered in the child's mind to form a first generalization over the words s/he has accumulated. This presupposes relevant grammatical knowledge, as well as a good storage and command of relevant morphology and syntax as well as phonology. For this reason, it is predicted that this stage emerges later and continues longer compared to other morphological processes like inflection. The first sign of the acquisition of the -ed rule is known to appear around the third year. In the case of rdk, the age at which it appears is unpredictable, but may well be later than this. It seems reasonable to speculate that the emergence of productive command for rdk is to be after at least 4 years of age when productive command of compound formation has been well established. According to Shirose and Kiritani's (2001) study of the acquisition of Japanese compound accent the majority of four and five-year-olds manage to produce simple two-element novel compounds such as *usagi-neko* (‘rabbit-cat’) from two pictured elements given, but more than half of the three-year-olds perform much less successfully.

As discussed in 5.12 and 6.2. above, it is largely unknown how a child learns rdk, but we know what a child learns: it is the linking [+voice] morpheme ‘p’ and the ranking of the faithfulness constraint **Realize-Morpheme over markedness** *[+voice, -son] that allows the morpheme to be parsed. This stage is considered to be a stage of various successful and unsuccessful rankings and rerankings characteristic of a particular learning path among range of possibilities. Among them are three worst scenarios in which opaque outputs are expected (shown in grey in the model (125) above; p193 Different learning paths are simulated in a way the key inputs to the learner
are encountered in the worst order imaginable (marked ‘®’), i.e. to deliberately trap the learner to set up an incorrect ranking before arriving at the target ranking. Two types of hypothetical immature rankings give rise to three erroneous phenomena: (1) overapplication of rdk, (2) underapplication of rdk and (3) devoicing of underlying [voice].

(1) Overapplication of rdk

One of the worst learning scenarios results in the overapplication of rdk. Overapplication of rdk refers to an application of rdk to a form to which it should not be applied. The form in question is of /soba/ type, and the expected overapplied output is of a *[yaki-zoba] type for the /yaki + p + soba/ type input. The result is a violation of LL. Note that “overapplication” here is not exactly a synonym to “overregul(general)ization” in two respects. One is that the term and concept of ‘regular’ or ‘general’ is inappropriate and misleading in rdk. The other is that it tells us more about the learner than what the phenomenon of overregularization (overgeneralization) does. Overapplication of rdk means not only that the learner has established a rdk-producing ranking which realizes the voicing morpheme p, but also that it is not mature enough (somewhat ill-ranked) in the sense that it does not fully cater for all the outputs expected from the target adult ranking.

As we discussed earlier in 4.3.4.4., OT explains that LL is not merely one of the conditions to rdk but is a part of the essential phonotactic knowledge, i.e., the syllable structure constraint in the Y stratum, due to the ranking: OCP[+voice, -son] » *[+voice, son], which should have been established prior to the acquisition of rdk. The learner is already equipped with the OCP[+voice, -son] from the start, and it is never
dominated by REALIZE-MORPHEME in the course of rdk acquisition. It is important to remember that in our OT prediction the overapplication of rdk or LL violation in *
[yaki-zoba] does not necessarily result from violating the OCP, but rather from the undesirably lower-ranked UNIFORMITY[voice]. In other words, it has been argued that LL should not be violated unless the wrong rdk grammar is formed during the acquisition of rdk. For this reason, we predict that theoretically, the violation of LL can be attributed to the Weak UNIFORMITY[voice] grammar; if so, we should expect rdk in the output of the /tabi + p + hito/ (VOb+Ob) type input because this grammar typically and incorrectly allows at most two voiced obstruents anywhere in its output. This is not to claim that the OCP is never violated by actual speakers (it is certainly a logical possibility, and we never know exactly what gives rise to an output like *
[yaki-zoba]), but our prediction gives more plausible explanation as to why it is violated if in fact it is.

(2) Underapplication of rdk

In the OT analysis, two rdk conditions LL and VOb+Ob are phonologically related phenomena, both result from the same constraints but in different rankings. Underapplication of rdk (e.g. /tabi + p + hito/ → *[tabi-hito]) results when the ranking for the overapplication of rdk is reversed. Underapplication of rdk means to fail to apply rdk to an item that should undergo rdk. This is caused by a voiced obstruent in the ‘first element’ of the compound. This is traditionally known as the “strong version of LL” (see 3.3.3.), now a defunct phonological rule/constraint. The child faithfully obeys not only the OCP but the incorrectly higher-ranked UNIFORMITY[voice] to disallow voice fusion anywhere in the output. This is due to an inadequate morpheme analysis caused
by the child’s lack of morpho-syntactic knowledge, rather than the knowledge of rdk itself.

Our hypothesis of the underapplication of rdk and the Strong UNIFORMITY[voice] grammar provides a new interpretation of the strong version of LL. Traditional analysis faces a problem accounting for an output like /tabi + hito/ → *[tabi-hito] because it has to resort to the explanation that the rdk rule has not yet been learned or still ‘wobbly’ and it occasionally fails. OT accommodates the two versions of LL, namely the strong defunct version and the modern weak version, under different rankings of the same constraint: UNIFORMITY[voice]. Since the split of UNIFORMITY[voice] into two domains M and G crucially separates the two LLs, the loss of the strong LL may be attributable to a diachronic development of the M/G split in history of the language, leaving only the weak version in function today. Thus, it has an advantage of adequately accounting for an output like [tabi-bito] by attributing it to the child’s immature rdk ranking rather than the knowledge of language change. It also justifies the idea that this form is logically possible even if the child uses rdk elsewhere.

(3) Devoicing of underlying [voice] (not tested)

This phenomenon is probably the most unlikely of all. It is in fact an extension of the underapplication of rdk. It ‘devoices’ any underlyingly voiced obstruent to satisfy the OCP because the ranking does not allow fusion of [+voice] across the morpheme boundary because the higher-ranked UNIFORMITY[voice] is not relativized to distinguish a morphologically complex form from a simple one. So, if the input contains two voiced obstruents, one in the first element and the other in the second (e.g. /tabi + p + gara/), neither the rdk morpheme p nor one of the voiced obstruents is parsed. The
output is either *[tabi-kara] or *[tahi-gara]. Although it is interesting to see if the child actually does this, it is not directly relevant to rdk, and is not tested in the study.

The two immature grammars and three opaque phenomena are proposed as the results of worst case learning scenarios. They are all logical possibilities, and we cannot be sure whether these intermediate versions of rdk grammar actually exist, and how long this stage lasts. However, there is no doubt that not all learners take the same learning paths; everyone has his or her own learning style. The learner will gradually produce fewer incorrect forms, abandoning his/her own innovative forms as s/he grows up. More grammatically complex structures and exceptions are accumulated, and more generalizations are made over their patterns, shaping up his/her rdk grammar to the target model. This is the topic of the next section.

As we can see from the table (125), it can be speculated that the sequential changes of rdk grammars give rise to a so-called U-shaped error pattern in the overall course of rdk development. The early grammars, both $L_0$ and $L_1$, produce correct outputs (with the underlying rdk [voice]), the intermediate grammars $L_2^{[sg]}$ and $L_2^{[sw]}$ can yield erroneous outputs like *yaki-zoba type (i.e. the overapplication of rdk) along with other correct usage, and the target full rdk grammar is expected to produce grammatical outputs (with the genuine rdk [voice]). Furthermore, it is likely that the use of nonsense words in the study may add a different kind of curve. The learning of various conditioning factors can influence the rdk occurrence rate and create a downward regression along the age continuum. This is because the more exceptions are accumulated and generalized, the more likely it is that such knowledge is (semi-)productively employed to precede the rdk rule application – what DMT calls the
over-irregularization of irregular patterns.

6.3.2. Learning of the conditioning factors

This section concerns the learning of the irregularity, or more appropriately, the inconsistent applicability of rdk. The important assumption we are going to make is that this is achieved via learning of the conditioning factors. It is a translation of what we have understood about 'irregular patterns' in the DMT model into the rdk context. The rdk conditions, specifically the phonological ones, are the very patterns that are memory-based and are not subject to a rule-based process. Such patterns are generalized in the form of abstract 'prototype schemata' to precede default processes. This leads to another important assumption. Some schemata block rdk, but some others do the opposite: giving rise to rdk voicing. This may sound contradictory, but this is what the rdk-inducing conditions, such as ACC and LV+, are supposed to do. The rdk obtained in this way is not rule-generated, but memory-generated via rdk-signaling schema although the two are indistinguishable at the surface. The learning of the rdk irregularity involves not only the pattern extraction but the extra step of deducing which pattern favours rdk and which one does not. Shown below in (126) is a list of the phonological conditions and their sample structures that will be incorporated in the study.
Phonological conditions on rdk and their sample structures

(N.B. ‘+’: morpheme boundary; ‘-’ a segment)

+Rdk conditions (i.e. ‘rdk-inducing’ phonological patterns)

/N+/: /---n/ + /--/ (first element ends in mora nasal)
LV+: /---oo/ + /--/ (first element ends in a long vowel)
ACC: /--/ + /--/ (4-mora unaccented compounds)

-Rdk conditions (i.e. ‘rdk-inhibiting’ phonological patterns)

LL: /---/ + /---/ (voiced obstruent in second element)
VOb+Ob: /---/ + /---/ (rdk creates adjacent identical voiced obstruents)
+[−VF]²: /---/ + /h-h/, /s-s/ (double voiceless fricatives in second element)
+/h//m/: /---/ + /h-m/, /h-n/ (second element consists of /h/ and a nasal)

The associations between listed items and their patterns are of ‘graded strength’
(Marcus et al. 1995:194). Since the rote learning favours frequency and similarity, more encounters with phonologically similar forms enhance the chance of that condition being strongly internalized. As discussed earlier in Chapter Five, people do use irregular patterns semi-productively, i.e. apply the patterns somewhat productively in word-formation via analogical processes, e.g. spling-splang (Bybee and Moder 1983; Prasada and Pinker 1993). Even children make similar errors like wipe-wope (Bybee and Slobin 1982; Pinker and Prince 1988; Xu and Pinker 1995). Then, the stronger the association is, the more likely it is that applicability of rdk is affected by it. By incorporating the patterns of phonological conditions into the test stimuli, we are able to see which condition is present and how strongly the condition affects rdk applicability.
It is expected that different conditions have different degrees of effect both positive and negative, except that LL should have the strongest inhibiting effect.

There is a convenient cover-term for various factors that facilitate the learning of the conditions, and that is an all-inclusive concept of “saliency”. The more salient (frequent, transparent, productive, etc.) a form is, the more likely it is to be patterned by the learner. In his study of “test 1” investigating how the rdk probabilities of the second elements in dictionary examples affect that of the same examples given in novel combinations, Vance (1979) concludes as follows:

“There is, of course, no real reason to expect the percentage of dictionary examples with rendaku to correlate particularly well with the number of rendaku responses in an experiment like test 1. The influence of existing examples with a given second element presumably depends to a large extent on how salient they are, and percentages of this kind are not likely to reflect saliency very accurately. One aspect of saliency is probably the sheer number of examples with or without rendaku. Any dictionary search introduces a bias in that highly productive second elements are not listed in all the compounds in which they occur since the class of such compounds is open. Frequency of use may be an even more important aspect of saliency. Thus, for example, a very frequently used word in which the second element shows rendaku may outweigh the influence of several uncommon words in which the same second element does not show rendaku.”

(Italics original; Vance 1979:96)

This is not to claim that the speakers do not make quantitative generalizations, but that the statistics in a dictionary do not always correlate with the associative strengths made by the learner. Unfortunately, without actual corpus data about how frequent such patterns are, we use frequency counts in dictionary examples for the time being as a rough approximation to the gradient strengths of the conditions. Then, the best
prediction we can make is that the Y stratum-specificity, LL, CC, RDPY and perhaps PX+ are most prone to generalization for their generality and consistency, and ACC for frequency. This is probably not the case for much less frequent and inconsistent factors, such as +/h//m/ which covers only a tiny fraction of words and is not exception free.

The learning of certain conditions presupposes relevant grammatical knowledge. In other words, a good storage and command of relevant morphology and syntax seems to be prerequisite to the generalization that the child makes over a particular pattern or types of words in question. For instance, the child would not be ready to extract a pattern of [D-O+P] (noun Direct-Object + verb-stem Predicate), no matter how frequently the child hears one, until s/he has become familiar with the syntax. Similarly, the child never recognizes the consistent absence of rdk in the M and F morpheme classes until s/he becomes competent enough to recognize the presence of such classes. Patterns like the LV+ found in more technical and advanced vocabulary might be generalized only by a small population of mature speakers. A –rdk condition like +{–VF} may require longer time to be encountered and generalized. In comparison, the phonological conditions may be more child-friendly in a sense that they could be generalized more easily and earlier than the conditions that require advanced grammatical knowledge. Within the child’s limited vocabulary, we do not have evidence to know which condition is salient for the young learner. Conditions like the ‘/N/+’ may have more appeal when the immature association is made with the ‘nasal cluster voicing’ constraint *NT that voices post-nasal obstruents in the Y and M classes, e.g.  

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14 The researcher’s own dictionary search (Kindaichi, H. and Y. Ikeda. 1988. *Gakken Kokugo Daijiten* Japanese Dictionary. Tokyo: Gakusyu Kenkyuysha.) shows that about 72% of compounds counted belong to the ACC (unaccented short compound) condition, and 74% of them show rdk.
tombo (‘dragonfly’: Yamato), unzari (‘disgusted’: Mimetic) (Itô and Mester 1999).

Personal factors such as educational experience, intelligence, knowledge of the language such as etymologies, etc. can further affect the kind, number or ordering of conditioning factors he/she eventually learns. It is highly possible that different learners may well internalize different sets of generalizations.

As a hypothesis the following three learning patterns of the rdk conditions can be posited:

**Pattern 1:** At the one extreme, there is a pattern which is not unreasonable, although unlikely, that none of the factors are internalized. This is due to limited exposures to such patterns which are too elusive for the learner to extract any generalizations. The lack of vital cues to the associative memory in terms of frequency and similarities is not enough for any strong associations to be formed. The learner in this case is the pseudo-rdk learner. It is not difficult to imagine how scarce such cue would be compared to the English irregular verbs. Picture an unfortunate child who hears the following random list of +rdk and -rdk compounds in one week: kin-zyo, uta-hime, yaki-soba, wa-giri, aka-bane, Siba-ta, yaku-syo, tosi-tuki, tabi-bito, mika-duki, uri-tukusu, yane-huki, kani-dukisi, tume-kiri, Yama-da, nuri-gasa-ire, kara-buki, ao-dake-basi. Even if the child encounters a hundred more like these it does not seem to help the child greatly to make any generalizations. The current learning pattern assumes that words like these are eventually learned before s/he becomes an adult speaker but as ‘indigestible lexical instances’. In this extreme case, the speaker does not have much of the sounding right/wrong intuition since the speaker’ s knowledge about rdk is a list of lexical items. Understandably, this type of learner does not learn rdk as a rule.
**Pattern 2:** This is the other extreme which is also not entirely dismissible; a maximum set of conditioning factors is eventually internalized. Since the sounding right/wrong intuition in this case is represented by a full collection of abstract schemata, it has to be highly specific, consistent and positively conscious compared to less memory-sensitive speakers. This type of learner has the maximum knowledge of rdk and is most likely to have symbolized rdk as a mental rule operation, because the very first step to learning rdk as a rule-based process is the pattern extraction. In a nonsense word experiment, this speaker is the most sensitive to the various rdk environments tested as a result of the interaction between the semi-productive use of the abstract knowledge and the productive application of rdk.

**Pattern 3:** Between the two extreme patterns above, there is a continuum of various patterns with random set of generalizations with varying degrees of strengths. Different conditioning factors are either internalized or simply memorized as instances by different speakers at different stages and times during his/her life. They all depend on inter- and intra-speaker differences and variations. Consequently, each speaker’s sounding right/wrong intuition displays wide variety. Probably the psychologically real status of rdk also varies: some may be less stable and all-encompassing compared to that in the pattern 2 above.
6.4. Summary

1. The rdk process is ‘regular’, but the phenomenon is ‘irregular’.
   
   In the DMT model, the regular-irregular split represents the default vs. non-default distinction in notion and mechanism. The terms “regular/irregular” are often misleading and inappropriate in rdk.

2. Rdk as a ‘mental rule’ operation
   
   The psycholinguistic notion of rule is relevant. The psychological reality of rdk is tested by its applicability to nonsense words. The chances are that this is unlikely. Our prediction is that rdk is too weak and elusive to signal a rule status. (a) There are many poorly defined conditions. (b) The stratum-specificity and lack of Y neologisms reduce cues for rdk as a default rule practice. (c) Neither the marking of rdk nor use of rdk compounds is obligatory, and is normally easily replaced by a phrase. (d) The non-default forms are those that are left rdk-less, hence even if a default is set to –rdk, which is a perfectly reasonable choice, it is unobservable. (e) There is a potential confusion in determining so-called regular and irregular forms in rdk. Due to the nature of the process, canonical roots and so-called irregular patterns become phonetically identical. This is certainly not a useful cue. (f) Some studies on inflection other than English suggest that rules may be learnt without a default.

3. Acquisitión of rdk
   
   Productive rdk will not be observed until 4 or 5. This stage is characterized by pseudo-rdk, correctly but lexically-generated instances. This could be investigated by an
informal compounding task involving real words somewhere during the test. At a certain stage in the course of development, the first rdk is expected to appear, probably during school-age years, indicating that rdk is learned as rule-based process by some learners. Those who do not learn it as a mental rule remain pseudo-rdk speakers (who do not apply rdk to nonsense forms). In a situation where no conditioning factors interfere (i.e. 'neutral' or condition-free rdk environment like /ori/ + /kami/) we expect a distinction between rdk-free children and rdk-producing adults. As for testing the effects of the rdk conditions, the phonological factors are tested most reliably by incorporating the patterns into nonsense items. In an environment where rdk-inducing conditions are tested, the rdk rate may show a gradual increase according to age for certain rdk-favouring conditions, such as LV+ and /N/+, which are characteristics of more advanced vocabulary. In the rdk-inhibiting environment, we will expect a gradual decrease of rdk rate as more and more rdk-inhibiting conditions are learned from the most general to the least. However, no rdk-inhibiting conditions are more effective than LL. No rdk should be observed under the LL condition at any stage except in very young children. LL violation results in very special circumstances; if and only if *tabi-bitō* type is heard but not *yaki-soba* type, which encourages the construction of an incorrect grammar that allows LL violation. We predict another defective type of grammar, and it allows only one voiced obstruent anywhere in the output. Thus, this special learner, who knows *yaki-soba* type but not *tabi-bitō* type, constantly obeys LL, and does not apply rdk under VOb+Ob condition.
Chapter Seven

THE STUDY

7.1. Objectives

There are two main objectives of this study. First, to see when and how rdk is acquired and developed, and secondly, to discover what kind of generalizations speakers actually make (and do not make) in the face of such a seemingly messy phenomenon. One way of investigating this is to see if speakers can apply generalizations productively to 'nonexistent (nonsense)' forms of an appropriate kind, and to what extent this occurs. This enables us to investigate rdk production in compounds in which the influence of the knowledge about existing words is minimized. The fundamental premise here is that responses to nonexistent items are a straightforward reflection of a speaker's unconscious knowledge. In other words, productivity is the central and crucial variable, and the basic manifestation of the rule/constraint-governed ~ lexicalized knowledge continuum of the speaker. If a condition fails to be productive in the sense that a speaker does not conform to it in handling nonexistent forms, it seems reasonable to infer that
the speaker has not made a generalization of that condition.

The following rdк conditions are tested:

(127) Rdк conditions to be tested

(1) ‘Рdk’: rdк production in condition-free environment
(2) ‘LL’ (−rdк): the blocking of rdк in /yaki + soba/ type input (OT predicts that the
‘overapplication’ of rdк – *[yakizoba] – is possible due to the incorrect constraint
ranking previously termed the “Weak UNIFORMITY[voice] problem”)
(3) ‘+[−VF]’2 (−rdк): the rdк-inhibiting effect of two identical morae containing a
voiceless fricative, e.g. /sVsV/, /hVhV/.
(4) ‘+/h//m//’ (−rdк): the rdк-inhibiting effect of initial /h/ followed by a mora
containing nasal, e.g. /hVnV/, /hVmV/.
(5) ‘/n/+’ (−rdк): the rdк-favoring effect of the A-word final mora nasal /n/
(6) ‘LV+’ (−rdк): the rdк-favoring effect of the A-word final long vowel
(7) ‘VOb+Ob’ (−rdк): the rdк-avoiding effect of a A-word final voiced obstruent,
particularly when the B-word initial voiceless obstruent is homorganic; (OT
predicts that this is the ‘underapplication’ of rdк in which /tabi + hito/ type input
surfaces non-rdк [tabi-hito] from the incorrect constraint ranking called “Strong
UNIFORMITY[voice] problem”).
(8) ‘ACC’ (−rdк): the rdк-favoring effect in ‘unaccented’ short nominal compounds.

The study was conducted ‘orally’, which is another important premise of the study. If
rdк is a naturally acquirable ‘productive’ phonological process and not the product of
their taught knowledge of the writing system (i.e. in the kana syllabaries, only the voiced obstruents are diacritically marked by adding dakuten – "the voicing dots" – to the kana representing a mora of "voiceless obstruent + vowel" such as ka ʰa and ga ʰa; see 2.2.), then even 'pre-literate' speakers should manage to acquire and then use it. For this reason, each subject is individually interviewed orally in order to minimize the bias of testing the subjects' conscious knowledge of literacy. This enables the experimenter to test all the subjects, both literate and illiterate, using the same material.

7.2. Test Design

7.2.1. Test stimuli

The stimuli are eight real Japanese words (all nouns) chosen from children's picture dictionaries15 and nineteen pseudo-Japanese ('ps-J' hereafter) words invented by the experimenter. These are shown in (128).

(128) Test stimuli: 'real' Japanese words and 'pseudo' Japanese (ps-J) words

(a) 'Real' Japanese words (8)

hasami /hasami/ ('scissors')

kame /kame/ ('turtle')

kutu /kutsu/ ('shoe')

megane /megane/ ('spectacles')

panda /panda/ ('panda')

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Different word combinations as first and second elements constitute a series of compounding tasks in which each of the rdk conditions are independently tested. The number of words is kept as small as possible by ‘recycling’ certain words wherever possible in order to minimize memory load for the subjects. For the same reason, all the words are either two or three morae in length. This limits the accentuation of resulting compounds to two predictable patterns (see 7.2.3. below).

The eight real words are prepared for demonstration, training and qualifying.
exercises. They are all 1) the names of familiar objects and animals, 2) known by infants, and 3) two or three mora long. Three of them serve as the first elements, and five as the second elements.

The ps-J words (128-b) fall into two types; seventeen of them are intended as pseudo-Yamato-Japanese (‘ps-Y-J’) words. They all satisfy the phonotactic characteristics of the Y morphemes of CVCV(CV) structure. Two of them, namely ‘hokun’ and ‘tetoo’, on the other hand, have the characteristics of non-Y words (but recall that the class of the first element may be non-Y). One ends in a mora nasal and the other in a long vowel. These are included to the conditioning factors (127-5) ‘/N/+’ (+rdk) and (127-6) ‘LV+’ (+rdk) already seen in 7.1.

7.2.2. Choice of segments

The segments used, particularly the consonants, in the ps-J words are chosen for the sake of simplicity. That is, they are easily pronounceable by the subjects. Affricated and palatalized consonant-vowel sequences such as \(t\ddot{i}\), \(s\ddot{i}\), \(z\ddot{i}\), etc. are avoided.

The sonorants are not used except for those testing ‘+/h//m/’ (127-4) and ‘/N/+’ (127-5); this is a precaution against indiscriminate blocking of rdk by the sonorants. Recall that sonorants never block rdk, although they are phonetically voiced. For some learners, however, this ‘underspecification’ ([-voice] for sonorants, [+voice] for obstruents (see Ito, Mester and Padgett 1995, for example) could be a problem which is not yet fully mastered.

Among the range of voiceless consonants susceptible to rdk, namely \(/k/\), \(/s/\), \(/t/\),
Chapter 7 – The Study

and /h/, the rdk-peculiar alternation of /h~/b/ receives a special treatment. It is logical
to suspect that the complication poses an extra learning load for the child and that it is
different from the other simple voicing alternations such as the velars /k~/g/, and
would be mastered relatively late in the acquisition process. In short, the /h/ is used only
in four words: two for testing the ‘+/h//m/’ (127-4) condition, one for the ‘+[-VF]2’
(127-3) condition, and one for testing solely the /h~/b/ alternation in rdk itself (127-1).

7.2.3. Word length, combinations and accent

As briefly mentioned above, there are several reasons for the test words to be two and
three mora long. First, one-mora ps-J words are practically impossible to think of.
Second, according to Nakano (1973), two-mora words show the highest token
frequency whereas three- and four-mora words have the highest type frequency in the Y
class of the language.16 Third, combining two and three morae words can create four
possible compound lengths of [2+2], [3+2], [2+3] and [3+3], which are sufficient for
testing independently the correlation between rdk and the accentuation patterns of
compounds. Recall that rdk becomes less likely when a nominal compound is short,
with the second element being two morae or less, and ‘accented’, with pitch fall within
a compound (e.g. LHLL) than ‘unaccented’, with no pitch fall, (e.g. LHHH). According
to the nominal compound accent rule of Tokyo Japanese (Kindaichi 1966; Ueno 1977;

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16 Nakano (1973) reports on the frequency and word-length based on 900000 words in newspapers that 2
and 3 mora words show the token frequency of 67% (40% 2-mora, 27% 3-mora) in the Y class. Type
frequency wise 50% (18% 2-mora, 32% 3-mora) of Y (following 33% 4-mora). Hayashi (1957), on the
other hand, reports on 47000 words in the NHK Japanese Accent Dictionary (1951) that 4-mora is the
most common word-length of the whole vocabulary of 38.8%.

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Kubozono 1995a, 1995b, 1997, 1998a, 1998b, 1999; Kubozono and Mester 1995; Akinaga 1966; Kubozono and Ōta 1998; Haraguchi 1999), compounds of [3+2] and [3+3] mora structures are regarded as ‘short’ and always ‘accented’. The following accent rule (129) is from Kubozono and Ōta (1998). Note that this rule holds for compounds whose first elements are three morae or longer, e.g. [3+2], [3+3].

(129) Compound noun accent rule (Kubozono and Ōta 1998:86)

(a) When the accent of the second member is placed on the final syllable, or the second member is unaccented, the accent of the compound noun falls on the antepenultimate mora.

(b) When the accent of the second member is not placed on the final syllable, the accent of the second member predominates.

A more unified account by Kubozono and Mester (1995) says that when the second element of a compound is less than five morae, the compound is always accented (except for a number of lexical cases). In short, [3+2] and [3+3] combinations generally yield accented compounds, and seem appropriate for separating out the accent variable ‘ACC’ from other rdk condition tests.

Fourth, it is known that when the first element is less than three morae, such as [2+2] and [2+3], the compound behaves differently and can be ‘unaccented’. The study uses [2+2] type to test the ‘ACC’ condition in contrast with the [3+2] and [3+3] types. Provided that both first and second 2-mora elements are ‘unaccented’, the resulting compound could well be ‘unaccented’.

17 They eliminate the conventional distinction between ‘short’ and ‘long’ compounds and propose a unified generalization as follows: “(a) When the second member of a compound consists of two bimoraic feet or less the accent of the compound falls on the penultimate foot. (b) When the second
All the ps-J words are presented orally as unaccented, i.e. LH, LHH. Statistically speaking, this is a reasonable treatment because over 50% of nouns, particularly those in the Y and S-J classes, are unaccented in Tokyo Japanese (cf. Yokoyama 1979 in Hayashi 1982; Akinaga 1966). This makes it possible to predetermined the accentuation patterns of each of the compound types as summarized in (130).

(130) Predicted accentuation patterns of compounds from two ‘unaccented’ elements

<table>
<thead>
<tr>
<th>No. of mora</th>
<th>Predicted accentuation patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 3 + 2</td>
<td>LHH+ LH → LHH-LL (accented)</td>
</tr>
<tr>
<td>b. 3 + 3</td>
<td>LHH+ LHH → LHH-HLL (accented)</td>
</tr>
<tr>
<td>c. 2 + 2</td>
<td>LH + LH → LH-HH (unaccented)</td>
</tr>
</tbody>
</table>

7.2.4. Visual stimuli: “strange objects”

Each of the ps-J words is presented to the subjects visually as well as orally. These ‘strange’ objects are either toys, pieces of furniture, DIY/gardening tools or handicraft parts of fairly unusual kind. The most important role of the objects is to visualize the concept of compounding and the relationship between the constituents and to make the task easier and more realistic. In addition, they can attract subjects of all ages and give something to look at, touch, smell, talk about and play with while being engaged in the task; they also serve as distractors to break away from routine of monotonous questions.
It is important that each object appears strange and lifeless so that the subjects are convinced by the unfamiliar name given to it. This is a necessary precaution against misinterpretation of the compounding task by a young pilot-test subject as a “naming game” in which the goal was to come up with something as original and unique as possible.

Each object is made mutually attachable via adhesive so that the subjects can see the [modifier-head] relationship of a transparent [noun + noun] compounding. As pictured in (131) below, the subject sees the first element (A-word): a ‘guest’ or ‘modifying’ object being attached to the second element (B-word): the ‘host’ or ‘head’ object.

(131) Ps-J compound formation using an ‘attachable’ object

7.2.5. Familiar toys

It became clear in the series of pilot tests that not all subjects are entirely happy playing with the strange objects. In order to attract younger subjects’ attention and maintain
their motivation and interest during the session, familiar toys like those in (132) are brought in for fun so that they do not get bored. Some of these toys also became emergency spares or substitutes in case of loss /damage of the objects and other unexpected circumstances (see 7.2.6.1. the ‘pre-test’).

(132) ‘Fun’ toys for infants/children
7.2.6. Tests

The study consists of three test parts:

i) Preparatory-exercise (the ‘pre-test’)

ii) Elicited compound production test (‘the production test’) and

iii) Compound acceptability (perception) test (‘the acceptability test’).

The outline of the test is shown in (133) (see Appendix 1 for the real test sheet in Japanese).

(133) The tests

1. Pre-test

Step 1 (demonstration): megane + panda ‘spectacle + panda’

Step 2 (exercise/qualifying trial 1):

1. megane + same 2. kutu + kame 3. hasami + sasori (sai)
   (‘spectacle’ + ‘shark’) (‘shoe’ + ‘turtle’) (‘scissors’ + ‘scorpion / rhino’)

Step 3 (exercise/qualifying trial 2):

4. kutu + kate 5. hasami + kate 6. kate + kame
   (‘shoe’) (‘scissors’) (‘turtle’)

2. The Compound Production test (18 items)

1. soketa + teke 2. keto + teke
3. hokun + kotate 4. soketa + kotate
5. soketa + seka 6. tetoo + kotate
7. tetage + kete 8. soketa + hateke
3. The Compound Acceptability test (18 items)
(N.B. question numbers in square indicates that they give +rdk version first)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Compound 1</th>
<th>Compound 2</th>
<th>Compound 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>megane-same</td>
<td>kutu-game</td>
<td>hasami-zasori</td>
</tr>
<tr>
<td>2</td>
<td>megane-zame</td>
<td>kutu-kame</td>
<td>hasami-sasori</td>
</tr>
<tr>
<td>3</td>
<td>kutu-kate</td>
<td>hasami-gate</td>
<td>kate-kame</td>
</tr>
<tr>
<td>4</td>
<td>kutu-gate</td>
<td>hasami-kate</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>hasami-gate</td>
<td>hasami-kate</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>hasami-zasori</td>
<td>hasami-sasori</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>hokum-kotate</td>
<td>soketa-zeka</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>hokum-gotate</td>
<td>soketa-seka</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>hokum-kotate</td>
<td>tetage-kete</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>hokum-bateke</td>
<td>tetage-gete</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>kokum-teke</td>
<td>keto-deke</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>keto-bateke</td>
<td>keto-teke</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>keto-kisa</td>
<td>keto-gisa</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>keto-bateke</td>
<td>keto-hateke</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>keto-zoda</td>
<td>keto-soda</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>keto-bateke</td>
<td>keto-hateke</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>tetoo-deke</td>
<td>tetoo-teke</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>tetoo-bateke</td>
<td>tetoo-hateke</td>
<td></td>
</tr>
</tbody>
</table>
7.2.6.1. Pre-test

The Pre-test consists of one [real + real] example (Step 1) and six [real + ps-J]/[ps-J + real] questions (Step 2 and 3):

Example (Step 1): \textit{megane + panda} (‘spectacle + panda’)

Questions (Step 2, 3):

1. \textit{megane + same}  2. \textit{kutu + kame}  3. \textit{hasami + sasori/sai}  
   (‘spectacle’ + ‘shark’)  (‘shoe’ + ‘turtle’)  (‘scissors’ + ‘scorpion/rhino’)
4. \textit{kutu + kate}  5. \textit{hasami + kate}  6. \textit{kate + kame}  
   (‘shoe’)  (‘scissors’)  (‘turtle’)  

It is an introductory ‘tune-in’ demonstration and preparatory training exercise designed to both prepare and assess/select subjects who are eligible for the production test to follow. It aims to –

1) introduce to the subject the type of task they have to perform,
2) confirm whether the subject is capable of valid compound formation
3) eliminate subjects who seem incapable of performing the main task of the study by encouraging the subject to form a novel but syntactically and grammatically correct compound from two words provided. It consists of three steps: ‘Step 1 demonstration, Step 2 training’ and ‘Step 3 qualifying trial’.

\textit{Step 1} gives an instruction to the basic compound task to be performed, using a miniature spectacles and a panda, demonstrating the important aspects of the task that:

1) the first object, presented first, constitutes the first element (A-word), and the second object, presented next, constitutes the second element (B-word) of a compound;
2) the first object always attaches itself to the second object, i.e. the two are in [modifier + head], [guest + host], or [attachment + base] relationship;
3) the first object is normally attached on top of the second object; the second object is usually bigger/larger than the first object.

A set of pictures in (134) demonstrates that the B-word *panda* ‘panda’ becomes *megane-panda* ‘spectacle-panda’ (a panda wearing spectacles). The objects are shown to the subject in the numbered order by asking what each object is called. Note that the foreign word panda is immune to rdk.

(134)  *Step 1* introducing *megane-panda* ‘spectacle-panda’

(1) A-word (first object)  (2) B-word (second object)  (3) [A+B] compound

![megane](image1) + ![panda](image2) → ![megane + panda](image3)

The subject is asked what the resulting animal (134-3) would be called. If the correct response *megane-panda* is not given, it is named by the researcher to be repeated and remembered by the subject. It is also explained why they should be so called rather than the other way around. This is the example to which the experimenter always referred back to if the subject appeared confused.

*Step 2* aims to check whether the subject can spontaneously produce more compounds using real familiar words. In addition, unlike *panda* above, it provides the
subject with an ideal rdk environment – in which no rdk-conditioning factors interfere – to see if rdk is observed. The three tasks in (135) below are given in the numbered order. Sai ‘rhino’ in question 3 are used in case a subject is not able to name sasori ‘scorpion’.

(135)  Pre-test Step 2: [real + real] (exercise/qualifying trial 1):

1. megane + same
2. kutu + kame
3. hasami + sasori/sai
   (‘spectacle’ + ‘shark’)  (‘shoe’ + ‘turtle’)  (‘scissors’ + ‘scorpion / rhino’)

Question 1. megane + same

![megane + same](image1)

Question 2. kutu + kame

![kutu + kame](image2)
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Question 3. **hasami + sasori**

![Image of hasami + sasori](image)

Compounding *megane + same, kutu + kame* and *hasami + sasori* (sai) create the rdk inducing environments of different word length, [3+2], [2+2] and [3+3(2)] morae, respectively. However, the difference is that *same* and *kame* are much more prone to rdk (they always undergo rdk in known compounds) than *sasori* and *sai* (compounds involving these two words are much rarer and less familiar). It is important that the subjects are able to name the animals by themselves to see whether they know the input/underlying forms.

This is followed by more advanced *Step 3* in which three more trials are given to see whether the subject can combine real words with a ps-J word “kate” (/kate/) as both A-word and B-word as in (136).

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(136) Pre-test Step 3: [real + ps-J] and [ps-J + real] (exercise/qualifying trial 2):

4. \textit{kutu} + \textit{kate}  
\text{('shoe')}  

5. \textit{hasami} + \textit{kate}  
\text{('scissors')}  

6. \textit{kate} + \textit{kame}  
\text{('turtle')}  

Question 1. \textit{kutu} + \textit{kate}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{kutu_kate.png}
\end{figure}

Question 2. \textit{hasami} + \textit{kate}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{hasami_kate.png}
\end{figure}

Question 3. \textit{kate} + \textit{kame}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{kate_kame.png}
\end{figure}
For the purpose of the pre-test, both +rdk and −rdk responses are accepted as long as the response is judged a syntactically well-formed compound. In order to pass the pre-test, a subject has to (i) give at least three instant correct answers in a row out of six, as well as (ii) making no more than two mistakes in a row which must be self-corrected after being asked once again. Those who score less are judged disqualified for the production test, and thus move straight on to the acceptability test.

During the pre-test the toys in (137), among the familiar ‘fun’ toys previously shown in 7.2.5. (132), catered for unexpected circumstances. The animals: monkey, bear, tiger, octopus, deer, fox and frog are all substitutes in case the regular animals in the pre-test B-words are not named or are named wrongly. The latter case was surprisingly common among three, four and even five year-olds; for instance, shark was often mistaken for *iruka* (‘dolphin’), *kuzira* (‘whale’), even *hikooki* (S-J; ‘airplane’), and scorpion for *zarigani* (‘lobster’). Even a popular substitute rhino (for scorpion) was occasionally mistaken for *kaba* (‘hippo’) and *kyooruu* (S-J; ‘dinosaur’). Since none of these were ideal for the pre-test purposes, the experimenter carried on showing more substitutes until they got one right. On some occasions, the substitutes were used for extra compounding exercises to double-check the marginal subjects. An extreme case was when two female infants were scared of the shark and scorpion and demanded that they be hidden away.

The mustache, blue hat, cup, fork and crystal ball (seen in the bottom) are for replacing the A-words when lost or damaged.
7.2.6.2. The production test: \([A \text{ (ps-Y-J)} + B \text{ (ps-Y-J)}]\]

The production test is designed to test productivity of rdk in various environments created by pairing different ps-J words. Subjects are shown two objects in sequence as described above. Given what the first object (A-word) and then the second (B-word) are called, the subject has to answer what the resulting object \([A+B]\) would be called. It is vitally important to ensure that the subject is convinced that it is a Japanese Y word. The protocol for the production test is given in (138):
(138) Protocol for eliciting a ps-J compound

Experimenter: “This object is called A (input 1).”
(showing object A to the subject)
“Here is another object. This name is B (input 2).
It is a Japanese (hiragana) name, not a foreign (katakana) name.”
(showing object B)
“Now, I am going to stick A onto B like this. Look, A is attached to B. What would you call it when A is attached to B? In other words, what makes A and B (output)?”
(showing object A+B)

It is emphasized that the name of an object is a Japanese name in hiragana (cursive kana typically used to write Y words), not a foreign name and it cannot be written in katakana (square kana used to write all foreign words).

A total of eighteen questions (pairs) are prepared to create three distinct rdk environments: ‘Neutral’, ‘+Rdk-conditioned’ and ‘–Rdk-conditioned’. Four pairs, referred to as ‘Rdk pairs’, create the condition-free, Neutral environment in which no particular conditioning factors are tested. Four ps-Y-J words “teke” (/teke/), “seka” (/seka/), “kotate” (/kotate/), “hateke” (/hateke/), all free of rdk-conditioning factors, are invented and paired with the A-word “soketa” (/soketa/) as in (139-1) – (139-4) to give total of four Rdk pairs of [3+2] and [3+3] mora structures. Rdk-4 aims to test the /h/~/b/ alternation separately from the other straightforward ones.
The Rdk pairs (ideal rdk environment) for the production test. **Total: 4 items**

1. soketa + teke
2. soketa + seka
3. soketa + kotate
4. soketa + hateke

The rest of the questions, fourteen in total, are the ‘Cdn pairs’ that are designed to investigate the effects of the conditioning factors on rdk occurrence. Only the phonological conditions are tested due to the methodological limitations of the test design, and to maintain the phonology-centered scope of the study. The pairs fall into three sub-groups: the CdnA pairs, in which the A-word is the rdk-conditioning variable, CdnB pairs, in which the B-word is the variable, and CdnAB pairs in which the pairing of A-word and B-word creates the variable.

The CdnA pairs include the following rdk conditions characteristic of the A-word:

1. /n/+: the rdk-favoring effect of the A-word final mora nasal /n/,
2. LV+: the rdk-favoring effect of the A-word final long vowel

A candidate that satisfies ‘/n/+’ condition of the A-word is “hokun” (/hokuN/), and that tests ‘LV+’ condition is “tetoo” (/teto:/), both combined with the B-words “teke” and “kotate” to yield four pairs in (140).

The CdnA pairs (A-word conditioning) in the production test. **Total: 4 items**

- /n/+:
  - CdnA 1. hokun + teke
  - CdnA 2. hokun + kotate
- LV+:
  - CdnA 3. tetoo + teke
  - CdnA 4. tetoo + kotate
The CdnB pairs investigate the following conditions attributed to the phonological property of the B-word.

1) LL: the blocking of rdk in /yaki + soba/ type input (OT predicts that the ‘overapplication’ of rdk – *[yakizoba] – is possible due to the incorrect constraint ranking termed “Weak UNIFORMITY[voice] problem”).

2) +[-VF]^2: the rdk-inhibiting effect of two identical morae containing a voiceless fricative, e.g. /s_s_/ , /h_h_/ where ‘__’ denotes the vowels.

3) +/h//m/: the rdk-inhibiting effect of the initial /h/ followed by a mora containing nasal, e.g. /h_n_/ , /h_m_/ where ‘__’ denotes the vowels.

Two and three morae words “soda” (/soda/) and “tetagé” (/tetagé/) are combined with the A-word “soketa” (/soketa/) to test LL (141-CdnB-1, 2). Both “soso” (/soso/) and “heheko” (/heheko/), combined with “soketa”, (141- CdnB-3, 4) aim to test the double voiceless fricatives in the B-words (+[-VF]^2) that tend to inhibit rdk. Similarly, “homi” (/homi/) and “hemote” (/hemote/) (141- CdnB-5, 6) test the rdk inhibiting structure of /h/ + nasal (+/h//m/).

(141) The CdnB (B-word conditioning) pairs in the production test. Total: 6 items

LL : CdnB 1. soketa + soda
     CdnB 2. soketa + tetage
+[-VF]^2: CdnB 3. soketa + soso
          CdnB 4. soketa + heheko
+/h//m/: CdnB 5. soketa + homi
         CdnB 6. soketa + hemote
Finally, the Cdn_{AB} pairs test the effect of the following conditions:

1) VOb+Ob: the rdk-avoiding effect of an A-word final voiced obstruent, particularly when the B-word initial voiceless obstruent is homorganic; (OT predicts that this is the 'underapplication' of rdk in which /tabi + hito/ type input surfaces non-rdk [tabihito] from the incorrect constraint ranking called "Strong UNIFORMITY[voice] problem").

2) ACC: the rdk-favoring effect in 'unaccented' short nominal compounds.

"Tetage" (/tetage/) and "kikezo" (/kikezo/) are invented specifically to create the environment of VOb+Ob along with the B-words containing homorganic initial obstruents "kete" and "sokito" (142-Cdn_{AB}-1, 2). Unaccented short nominal compounds of [2+2] are created by "teke" and "kisa" to produce a pair "keto + teke" (LHHH) and "keto + kisa" (LHHH) as in (142-Cdn_{AB}-3, 4).

The Cdn_{AB} pairs (A+B conditioning) in the production test. **Total: 4 items**

- **VOb+Ob:**
  1. Cdn_{AB} 1. tetage + kete
  2. Cdn_{AB} 2. kikezo + sokito

- **ACC:**
  3. Cdn_{AB} 3. keto + teke
  4. Cdn_{AB} 4. keto + kisa

All eighteen questions (and the objects used) are shown in (143-1) – (143-18) in the order of presentation.
The production test questions

Question 1. soketa + teke

```
soketa  +  teke  →  soketa + teke
```

Question 2. keto + teke

```
keto  +  teke  →  keto + teke
```

Question 3. hokun + kotate

```
hokun  +  kotate  →  hokun + kotate
```
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Question 4. soketa + kotate
“soketa” + “kotate” → “soketa + kotate”

Question 5. soketa + seka
“soketa” + “seka” → “soketa + seka”

Question 6. tetoo + kotate
“tetoo” + “kotate” → “tetoo + kotate”

Question 7. tetage + kete
“tetage” + “kete” → “tetage + kete”
Question 8. soketa + hateke

"soketa" + "hateke" → "soketa + hateke"

Question 9. keto + kisa

"keto" + "kisa" → "keto + kisa"

Question 10. soketa + soda

"soketa" + "soda" → "soketa + soda"
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Question 11. soketa + tetage

```
soketa
```

```
tetage
```

```
soketa + tetage
```

Question 12. kikezo + sokito

```
kikezo
```

```
sokito
```

```
kikezo + sokito
```

Question 13. soketa + hemote

```
soketa
```

```
hemote
```

```
soketa + hemote
```

Question 14. soketa + heheko

```
soketa
```

```
heheko
```

```
soketa + heheko
```

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Question 15. hokun + teke

"hokun" + "teke" → "hokun + teke"

Question 16. soketa + homi

"soketa" + "homi" → "soketa + homi"

Question 17. tetoo + teke

"tetoo" + "teke" → "tetoo + teke"
Question 18. soketa + soso

7.2.6.3. The acceptability test

Following the production test, the subjects move on to the compound preference test ('Acceptability test') involving the same compounds used in the production test and pre-test. This final part of the session explores if there is any gap between rdk production and perception. On hearing two possible pronunciations of the same pair, i.e. one with rdk (+rdk) and the other without (−rdk), read aloud in the same order by the experimenter who is a native speaker, the subjects have to choose the one that s/he likes better than its counterpart. To minimize the possibility of the 'recency effect', twelve of the questions randomly give +rdk version first, and the rest give −rdk version first. For example, one hears “soketateke (pause) soketadeke” (for [soketa + teke]); then occasionally hears the reversed type like “ketodeke (pause) ketoteke” (for [keto + teke]). The subjects are advised that 1) they have to choose the one they ‘like’ on hearing two
versions of the same word, 2) the answers they will give in the acceptability test do not have to match those given in the Production-test, 3) not to answer by pronouncing the whole compound s/he chooses, but rather by saying “the first (one)” or “the second (one)”.  

7.3. Subjects

Subjects are selected groups of normal, monolingual, linguistically-naïve native speakers of standard Tokyo Japanese (all belonging to one dialect/accent group). The ages of the qualified subjects ranged from 3;8 to 37;11. They are divided into two large age groups: 82 non-adults (below age of 13 down to 3;8) and 49 adults (13 and above up to 37;11). A total of 149 subjects were interviewed, 13 failed the pre-test (compounding exercises) and 136 proceeded to the production test, in which 5 were unsatisfactory for various reasons and thus disqualified. A total of 131 (68 males and 63 females) successfully completed the whole test. The breakdown of subject numbers per age-group is shown below in Table 5.
Table 5. Breakdown of Qualified/disqualified Subjects

For each age group the number of qualified M(ale), F(emale) subjects who completed the whole test over total number of subjects interviewed (%) are shown.

<table>
<thead>
<tr>
<th>Age group</th>
<th>M</th>
<th>F</th>
<th>No. qualified/ No. interviewed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-14</td>
<td>7</td>
<td>4</td>
<td>11/11 (100.00%)</td>
</tr>
<tr>
<td>15-16</td>
<td>5</td>
<td>6</td>
<td>11/11 (100.00%)</td>
</tr>
<tr>
<td>17-21</td>
<td>4</td>
<td>5</td>
<td>9/10 (90.00%)</td>
</tr>
<tr>
<td>22-29</td>
<td>6</td>
<td>5</td>
<td>11/12 (91.67%)</td>
</tr>
<tr>
<td>30 &lt;</td>
<td>4</td>
<td>3</td>
<td>7/7 (100.00%)</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>23</td>
<td>49/51 (96.08%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age group</th>
<th>M</th>
<th>F</th>
<th>No. qualified/ No. interviewed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adults (3;0~12;11 years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td></td>
<td>2/10 (20.00%)</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>4</td>
<td>12/16 (75.00%)</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>5</td>
<td>10/11 (90.91%)</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>3</td>
<td>9/11 (81.82%)</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>2</td>
<td>7/7 (100.00%)</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>3</td>
<td>6/6 (100.00%)</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>5</td>
<td>8/8 (100.00%)</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>6</td>
<td>11/11 (100.00%)</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>6</td>
<td>8/8 (100.00%)</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>6</td>
<td>9/10 (90.00%)</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>40</td>
<td>82/98 (83.67%)</td>
</tr>
</tbody>
</table>

Grand total: 131 (82+49)/149 (87.92%)

All the subjects have resided in and around Tokyo since they were born or at least since the beginning of primary school. The non-adults (mean number of subjects per age: 8) include a large group of infants from a nursery in Totuka city (Kanagawa prefecture) and another large group of children from a primary school in Tama city (Tokyo); the rest are from Yokohama city (Kanagawa), Kosigaya city (Saitama) and central Tokyo. The adults are from Yokohama, Saitama prefectures and central Tokyo.

The subjects under age of 18 (school students, children and infants) are those who have been formally approved by their parents/guardians, class teachers and head teachers via a letter also describing the purpose, information/privacy protection policy,
7.4. Setting and Procedure

All the subjects participated on a volunteer basis. The study was carried out between 15th of July and 10th of October, 2002. All the subjects were individually interviewed in a quiet room allocated by the company, colleges, or schools where they work/study, or in individual households.

Each session was recorded on both DAT and MD recorders (see 7.5. Apparatus below). One session lasted around 15 minutes for the adult subjects, and 30 minutes or often more for the non-adult subjects who enjoyed talking/playing. For the comfort of children and infants, they were allowed to sit anywhere they preferred, and play with whatever toys they liked during a session. A female assistant was present during sessions to assist the experimenter and the subjects in various ways, such as escorting them into/out of the session room, adjusting room temperature, offering drinks/sweets and presents, playing with those who were waiting, talking to the parents, checking recording equipment and conditions.

A session started with general conversation to warm up the atmosphere and get to know each other so that subjects were relaxed and actively involved in talking. Following brief questions about the subject’s background information, e.g. name, age, birthday, how long s/he has lived in the area, etc., the subject is reminded first that the session is not a test, but rather a ‘Japanese word game’ in which the subject takes the teacher’s role to solve the problems the experimenter has brought. Secondly, there will
be no right or wrong answers; what the subject says is the answer. Normally, subjects are the ones who start the talking by asking what the objects are for, where they came from and what they are called. The experimenter usually replied, “That’s exactly what we are going to do today. I am here because I want you to teach me a lot of new Japanese words by combining all this.” This flow of conversation is normally the case for subjects of all ages.

The experimenter begins the pre-test Step 1 (demonstration) by explaining: “It would be easier if I show you an example of what we are going to do. Here we go. What is this?” The first object is a miniature spectacles followed by a panda. The experimenter lets the panda wear the spectacles, and asks what the spectacle-wearing panda would be called. The subjects had to learn and agree that the compound megane-panda is the only acceptable answer and that the least acceptable of all is the syntactically reversed, i.e. panda-megane. More tolerant feedback was given to responses, for instance megane o kaketeiru panda ‘panda that is wearing the spectacles’, megane no/to panda ‘panda with/and spectacles’ (phrased), mega-pan ‘spec-pan’ (clipped), otoosan-panda ‘father-panda’ (A-word replaced), me no warui panda ‘short-sighted panda’, etc., that these are quite possible and appreciated, but not what the experimenter was looking for. Most responses like these were self-corrected by telling them: “can you make it shorter/longer?” or “can you use my words instead?”

After this demonstration, the pre-test moves on to Step 2, announced to the subjects as ‘basic’ exercises, in which three [real + real] compounding trials are given. These are [megane + same] (‘spectacles’ + ‘shark’), [kutu + kame] (‘shoe’ + ‘turtle’), [hasami + sasori] (‘scissors’ + ‘scorpion’), or occasionally sai “rhino” for those who did not know scorpion. Step 3, called ‘advanced’ exercises, introduces a new ps-Y-J word
“kate” (/kate/) as in [kutu + kate], [hasami + kate], and [kate + kame]. During these trials, the first priority is to check if the subject has produced syntactically correct compounds regardless of +rdk or −rdk. The subject had had to score straightaway at least three times in a row out of six without making more than two mistakes in a row. A response was judged ‘mistake’ when it was self-corrected after being asked: “Is it? Do you remember what megane and panda makes?”

Despite the fact that the production-test was named the ‘application challenge’ in the sense that it uses entirely unfamiliar words and objects, the subjects were told that this is neither a memory test nor tongue-twister, and advised to seek help anytime they had forgotten the words/names, and to speak at their own speed and time. In addition, it was emphasized once again that there is no right or wrong answers (except the syntactically reversed), and that it is the subject’s own opinion that counts, not what it should be called or what people call it. All the objects are hidden until the testing begins. As in the protocol (138), the experimenter pulls out the first object and names it slowly, then names the second, attaching one to the other, holding both in his hands (occasionally they are held in the subjects’ hands). Then the experimenter asks, “now, what would you call it when A is attached to B? In other words, what makes A and B?” The experimenter responds to the subjects by saying either “Yes”, “Okay”, “Good” or “Great”, depending on the atmosphere of the session or the age and character of the subject. No particular distracting items were prepared since all the objects and toys brought into a session were used to break up the session every few questions. Normally the production test alone took more than 30 minutes for younger subjects to complete due to the amount of activity required. Those who completed the pre-test but not the production-test were not qualified or assessed. Most subjects took longer producing
longer compounds than shorter ones, and constant reminder of the object names was necessary.

During the whole session, the experimenter makes no comments on rdk. Whenever a subject is being indecisive between +rdk and −rdk responses, the experimenter usually waits and encourages the subject to choose one by saying “take your time. It’s your choice.”

The session finishes off with the compound acceptability test in which subjects have to choose the one they like from +rdk and −rdk versions of one compound, e.g. between soketa-teke (−rdk) and soketa-deke (+rdk). The word ‘like’ is used intentionally by the experimenter to leave the criteria of preference up to the subjects. The subjects were reminded on the following points. First, this is the final part of the session, no more strange words and so it will not take long. Second, answer by ‘the first’ or ‘the second’ rather than repeating the whole word they have chosen. This saved the younger subjects from mispronouncing or forgetting what they wanted to say. Finally, their answers do not have to be the same as those in the production test. It is a task independent from the production test, not intended to check what they have produced previously. The order of which version appear first is randomized. Younger subjects were constantly allowed plenty of time to break away from the repetitive questions whenever they felt like it, and come back whenever they were ready for another one or two.
Chapter 7 – The Study

7.5. Apparatus

Two sets of recorder and stereo microphone were used for live recording of an entire session. The main recording was done by SONY portable DAT® recorder and SONY® stereo microphone for MD/DAT. Supplementary recording, in case of power failure, mechanical problem, overtime recording, etc., was done by a SONY® portable MD recorder with extra batteries and stereo microphone for MD.
Chapter Eight

RESULTS AND DISCUSSION

8.1. Introduction

This chapter presents the results of the study with relevant analyses and discussions on findings and their implications. In this study, the prime focus was given to the production test. This investigated the native speakers' productive use of rdk knowledge in novel words as the most promising source of evidence for the psychological reality of rdk. The chapter begins with the overview of the test, showing the total number of +rdk responses and their distributions by age group. The responses are then separately analyzed according to three different rdk environments to investigate the effects of the conditioning factors proposed earlier. This is followed by sections of more detailed examinations of the specific points of inquiry outlined in the hypotheses, namely the violation of LL, the 'pseudo-rdk' phenomenon, and item analysis. The final section of the chapter is devoted to a discussion of the acceptability test as a possible source of supplementary evidence for the knowledge of rdk in mental representations, and of well-formedness constraints in general.
The following table shows the breakdown of the subjects analyzed in the study.

Table 6. Breakdown of qualified subjects

<table>
<thead>
<tr>
<th>Non-adults (3;0 – 12;11 years)</th>
<th>Adults (13;0 – 37;11 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Male</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
</tr>
</tbody>
</table>

Grand total: 131

For statistical analysis, the subjects have been pooled into fourteen age groups of 3-4, 5, 6, 7, 8, 9, 10, 11, 12, 13-14, 15-16, 17-21, 22-29, and 30-37, to make the number of subjects per group reasonably even. The number of subjects in each of these groups is shown in the table above. The first nine age groups up to 12 years are referred to as the ‘non-adults’ (infants and primary school children), and those above 13 years are the ‘adults’ (junior high/ high school students and adults).
8.2. Production Test

8.2.1. Overview

The analysis of the production test is based on a total of 2358 compound responses produced orally by 131 subjects (18 questions per subject) who passed the pre-test qualifying trial involving real words. Figure 1 is a histogram for mean percentages (%) and standard deviations (‘SD’ shown in vertical lines) of +rdk responses for each age group in the production test. The dotted line shows the number of rdk responses (%) obtained in the ‘neutral’ environment in which none of the rdk conditioning factors are tested. In principle, this is the environment where rdk should apply if it is rule-governed. The bars indicate the level of statistical significances for numbers between the bridged groups as revealed by a chi-square ($\chi^2$) test. All groups above the age of 11 had a significantly higher +rdk responses rate than each of the younger age groups.
What is striking is the fact that rdk production is virtually absent before the age of 11. As we have predicted in chapter 6, this seems to be the 'no rdk' stage, yet it was found to be surprisingly long. The data clearly shows that rdk production is essentially an adolescent-adult phenomenon. If the productive command over rdk emerges so late, it is probably one of the latest cases of morphophonemic acquisition ever observed. This is far beyond the age we speculated. The productive application of rdk seems to lag dramatically behind productive nominal compound formation. In turn, it implies that the rdk compounds seem purely to be part of lexical knowledge until the speaker graduates from primary school at average age of 12. The critical age seems to be around age 11 where a significant increase ($p < 0.01$) of +rdk responses first appears. This coincides well with the time when children enter junior high schools to learn Japanese grammar systematically for the first time. A significantly positive developmental trend continues
through the adolescent period (age 11 to 12: $\chi^2 = 8.30, p < 0.01$; age 12 to 13-4: $\chi^2 = 6.47, p < 0.05$). This is probably triggered by the sudden growth in advanced vocabulary as well as significant changes in cognitive skills, academic awareness, and social life in general that take place during this period, rather than the knowledge of the language itself. This may be an indication that the acquisition of rdk is largely due to an increased function of ‘general cognition’ rather than that of the language faculty, and that rdk may not necessarily be a process that is learned subconsciously in early childhood, but can be a consciously-learned process that is peripheral to or external to one’s language faculty. Interestingly, there is a noticeable decrease in production rate at around age of 17-21 years, making the course of development look very much like a ‘U-shape’. A closer examination of the data reveals that this is partly because there are a comparatively larger number of zero-rdk subjects (who produced 0% rdk) in 15-16, 17-21 and 22-29 age groups, but largely due to the outstandingly high +rdk rates by a few individuals in 13-14 and 30-37 age groups (this can be observed in Figure 2 below; see Appendix 3 for grouped distribution figures).

The results show that rdk was indeed applied productively to nonsense words, supporting rdk as a rule-generated process. However, the surprisingly low productivity implies its marginal status. It could be marginal if the rdk we see were produced only by a small group of people or if rdk were applied to only a few words across the subjects. As the dotted line shows, the lowest rate is 0.00%, and the highest rate barely reaches 30% in the environment where it could have reached 100%. This is no way near the 90% productivity of English -ed rule (Kim et al., 1991). As we will see, rdk is both a marginal and a weak process. Table 7 shows the proportion of +rdk subjects and the number of +rdk responses of adults and non-adults. The rows in gray give the rdk
frequencies obtained in the *Neutral* (condition-free) environment where rdk should apply if it is rule-based.

Table 7. Production: +rdk frequencies, non-adults vs. adults

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No. of +rdk subjects (%)</th>
<th>No. of +rdk responses</th>
<th>(Mean % of +rdk responses ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adults</td>
<td>6/82 (7.32%)</td>
<td>35/1476</td>
<td>(2.37% ± 11.71)</td>
</tr>
<tr>
<td><em>Neutral</em></td>
<td>4/82 (4.88%)</td>
<td>8/328</td>
<td>(2.44% ± 12.80)</td>
</tr>
<tr>
<td>Adults</td>
<td>26/49 (53.06%)</td>
<td>170/882</td>
<td>(19.27% ± 23.93)</td>
</tr>
<tr>
<td><em>Neutral</em></td>
<td>18/49 (36.73%)</td>
<td>42/196</td>
<td>(21.43% ± 31.46)</td>
</tr>
<tr>
<td>Total</td>
<td>32/131 (24.43%)</td>
<td>205/2358</td>
<td>(8.69% ± 20.50)</td>
</tr>
</tbody>
</table>

These figures confirm our earlier observation that the productive use of rdk is essentially adult-specific. The overall rdk productivity for the adults is 19.27% and 2.37% for the non-adults. The difference is statistically highly significant ($\chi^2 = 198.72$, $p < 0.001$). Also highly significant is the difference in the number of subjects who produced rdk ($\chi^2 = 34.77$, $p < 0.001$). Rdk is completely absent from 99 subjects of 131 (approx. 76%). Surprisingly, this includes 23 adults, which corresponds to nearly half of the adult population. Rdk is certainly not shown to be productive nor to be psychologically real at least for these subjects. The subjects’ knowledge about rdk is probably rote-based (lexical) rather than rule-based (grammatical). This is supported by the fact that in the pre-test 21 out of these 23 adults did give +rdk responses in the real words. The non-adults show similar results. The figure above tells us that there are 76 children who showed no rdk in the production test. However, 46 of them did produce rdk in the real words; the youngest being 3;11 years. This seems to support one of the predictions: the pseudo-rdk phenomenon. The reasonable conclusion to be drawn from
these facts is that as for the adults, rdk is a psychologically real process only for about half of the adult population. The other half appears to be handling rdk lexically. As for the non-adults, the vast majority are probably in the process of learning rdk by associative memory alone. A more detailed discussion on the types of subjects and the pseudo-rdk phenomenon will be taken up later in 8.2.5. and 8.2.6.

There exists an unlikely but not entirely dismissible explanation for the lack of productivity. Recall that the absolute precondition for rdk is that the second element must be a Y word. Since the stimuli are all nonsense words, we cannot deny the possibility that not all subjects were entirely convinced that they were Y words. Although an attempt was made to maximize the likelihood that they are viewed as such (see 7.2.1., 7.2.6.2.), this is a significant, potential factor that might have influenced the rdk occurrence rate, and is one of the inevitable shortcomings of an experiment of this kind.

We now turn to a closer examination of the individual response pattern for each subject. Figure 2 is a scatter diagram for +rdk of individual subjects by age group in the production test (for the exact statistics on grouped +rdk distribution, see Appendix 3). Subjects who violated LL are marked by ‘LL’ followed by the numbers ‘2’ for “soketa-soda” and ‘3’ for “soketa-tetage” to specify the location of a voiced obstruent in the second elements of the stimuli in which a violation is observed.
Figure 2.
Production: +rdk responses by individuals
A close observation of the distribution reveals that the sharp increase in the number of +rdk responses between ages 11-12 is achieved solely by three outstanding individuals. Two of them, a male school child (12;1) and a female junior high school student (13;4), scored the highest rate of 94.44%, exceeding the maximum rate of 88.89% in the case of fully-productive rdk (16 out of 18 stimuli excluding 2 items testing LL), at the expense of violating LL. Interestingly, these subjects show exactly the same response pattern giving +rdk to 17 responses of 18 except in [soketa-soda]. It is difficult to draw any firm conclusion from this, but the case we have here may be regarded as the Weak UNIFORMITY[voice] grammar ($L_2^{\ominus W_1}$) resulting in a type of error called 'overapplication' of rdk, namely in LL violation (in principle, the mechanism behind the overapplication error is essentially equivalent to what gives rise to overgeneralization errors in inflectional morphology). In addition, rdk is 'maximally-general (i.e. fully productive)’ in that rdk for these subjects is probably a newly-acquired unitary process with no conditions attached: there is no form or pattern in memory to block the application of rdk. The basis for assuming that this is the case of maximum-generalization is that it is applied almost ‘across-the-board’ when compared to any other subjects, and that both of the highest rdk-applying subjects appear at the earliest phase in the course of development. This case requires further empirical study for firmer conclusion.

Probably it is fair to conclude that the first rdk production as a group tendency is during junior high school years (13-14 years), where rdk was produced by 7 subjects out of 11, 25.76% of the population. The earliest rdk appears at age of 7 by a single individual (7;11), followed by an 8 year-old (8;5) both producing two +rdk responses each. These, however, are not significant (Fisher’s Exact test). If these +rdk responses
are genuine production and not articulation errors (e.g. slips of the tongue), these young subjects are certainly very exceptional individuals.

The next section looks more closely at the effects of various rdk environments that characterize the irregularity of rdk phenomenon. Two antagonistic environmental effects as well as the neutral environment are tested by three groups of prototype stimuli each incorporating certain phonological patterns of the conditions under investigation.

8.2.2. The effects of the rdk conditions

Various rdk conditions are incorporated into the test items in order to investigate the effects of the conditioning factors on rdk production. There are three environments: ‘+Rdk’ (rdk-inducing) environment, ‘−Rdk’ (rdk-inhibiting) environment, and ‘Neutral’ (condition-free) environment. Accordingly, each rdk condition tested in the study falls into one of the three types: +Rdk conditions, −Rdk conditions, and those without any conditions. First, Figure 3 shows the number of +rdk responses (%) for each rdk environment by age.
The adults show significantly higher percentage of +rdk responses than the non-adults in all three environments: ‘Neutral’ ($\chi^2 = 51.26, p < 0.001$), ‘+Rdk’ ($\chi^2 = 108.44, p < 0.001$), ‘–Rdk’ ($\chi^2 = 43.48, p < 0.001$). The expected effects of the two opposing environments are clearly visible. It shows that at least for the adult subjects, some of the rdk conditions both +Rdk and –Rdk, are an internalized part of their rdk knowledge, and that they responded accordingly. In other words, certain generalizations have been made over the phonological properties of the exceptions to rdk and this knowledge is used in the production of novel compounds.
As the relative movements of the black, blue and red lines show, knowledge about the +Rdk and -Rdk conditions seem to be present from an early development stage. The negative effects of the -Rdk conditions consistently result in lower +rdk responses than the other environments. At some point during the early phase of development the subjects seem to become more sensitive to the rdk-favouring environment, (indicated by the sharp-rising blue line) than to the rdk-inhibiting environment, implying a difference in sensitivity between the age groups. Overall, however, it was found that the environments had no significant influence on the non-adults’ rdk production. For the adults, on the other hand, the rdk-inhibiting factors seem more effective than the rdk-inducing factors. This is indeed the case, as shown in the next table.

Table 8 shows the results of χ² test on the number of +rdk responses over the appropriate total (%±SD) of 49 adults in the three environments. ‘P-value’ indicates the level of statistical significance between the bridged variables (non-significant values are not shown). As far as the adults’ rdk is concerned, only the -Rdk conditions have a significant effect on their rdk production compared to the environments without such conditions. The difference in effects becomes strongest and highly significant when the two opposing environments are contrasted. Thus, the adults’ rdk production is sensitive to the -Rdk conditions, which suggests that the -Rdk conditions exist as a psychologically significant part of the adults’ internalized knowledge of rdk.
Furthermore, the results of Mantel-Haenszel (M-H) $\chi^2$ test found a significant 'trend' ($M-H \chi^2 = 5.42, p < 0.05$) for linear increasing proportion of $+\text{rdk}$ responses in the adults' rdk production from $-\text{Rdk}$-conditioned, Neutral to $+\text{Rdk}$-conditioned. In other words, the adults' rdk production is sensitive to the gradient effects of the three major rdk environments. In sum, these results confirm that the adults seem to have knowledge of the rdk conditions as well as their opposing effects, and this is probably the basis of their sounding-right/wrong intuitions.

### 8.2.3. The effects of $+\text{rdk}$ conditions

The $+\text{Rdk}$ conditions, those that create rdk-inducing environments, include ‘ACC’ (unaccented compound), ‘$/\text{N}$/+$’ (first-element ending in mora nasal), ‘LV+$’ (first element ending in long vowel). This section looks at the effects of these conditions individually. Figure 4 shows the number of $+\text{rdk}$ responses (%±SD) of non-adults and adults in two different environments, Neutral and $+\text{Rdk}$-conditioned. The bars indicate...
the level of statistical significance for numbers between the bridged groups.

**Figure 4.** Production: rdk-inducing effects

Statistically, it was found that none of the +Rdk conditions had any significant effect for either adults or non-adults. It follows that none of the +Rdk conditions constitute generalizations that significantly affect the adults’ rdk production. As for the /n/+ and LV+ conditions, the results support Vance’s (1979:111) findings that there are no psychologically real tendencies of the claim that rdk is most likely after nasals and next most likely after long vowels (Sakurai, 1966; Okumura, 1980), although this is one of the well-known and most-quoted tendencies of rdk. The same can be said of the claim that the ACC (‘unaccented’ compounds) condition makes rdk more likely. According to the researcher’s own dictionary search\(^\text{19}\), four-mora compounds of [2+2] structure show

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the highest type frequency in the Y vocabulary, approximately 75% of nominal and verbal compounds listed, and about 76% of them show rdk. Thus, a higher +rdk percentage in certain types of dictionary examples is not necessarily a determining element of saliency that affects the speakers' judgments about rdk.

### 8.2.4 The effects of −rdk conditions

The rdk-inhibiting environments are created by the ‘−Rdk conditions’ comprising ‘LL’ (Lyman’s Law), ‘VOb+Ob’ (voiced obstruent followed by a homorganic voiceless obstruent), ‘+/h//m/’ (/h/ and nasal in the second element), and ‘+[−VF]’ (double voiceless fricatives in the second element). Figure 5 shows mean percentages and SD of +rdk responses of the non-adults and adults in Neutral and the various −Rdk-conditioned environments. The bars with p-values indicate statistical significances between the bridged groups.
No significant inhibiting effects are found for the non-adults’ +rdk rates. For the adults, individual -Rdk conditions appear to have varying inhibiting effects. The adults’ +rdk rate under LL is the lowest. In fact, as indicated in Table 9 below, LL is the only condition that affected the adults’ rdk significantly. The results of risk-analysis revealed that the likelihood to fail to apply rdk is significantly elevated by 4.2 (95% CI = 1.53-7.01) in the LL environment ($\chi^2 = 11.73, p < 0.001$) compared to the Neutral environment. Table 9 shows the level of statistical significance ($p$ value) between the various environments. The ‘+[-VF]^2’ condition has the weakest effect along with Neutral. The two conditions ‘+/h//m/’ and ‘VOb+Ob’ show a moderate, intermediate effects along the Neutral/+[-VF]^2 – LL effect continuum.
Table 9. Production: rdk-inhibiting effects on adults

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>+[-VF]^2</th>
<th>+/h//m/</th>
<th>VOb+Ob</th>
<th>LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of +rdk responses</td>
<td>42/196</td>
<td>16/98</td>
<td>13/98</td>
<td>13/98</td>
<td>5/98</td>
</tr>
<tr>
<td>(Mean % ± SD)</td>
<td>21.43%</td>
<td>16.33%</td>
<td>13.27%</td>
<td>13.27%</td>
<td>5.10%</td>
</tr>
<tr>
<td></td>
<td>± 31.46</td>
<td>± 29.56</td>
<td>± 26.57</td>
<td>± 26.57</td>
<td>± 15.29</td>
</tr>
<tr>
<td>p value</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td></td>
<td>p &lt; 0.001 (\chi^2 = 12.97)</td>
<td>p &lt; 0.01 (\chi^2 = 6.45)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of M-H \chi^2 test show that there is a significant trend for a decreased proportion of +rdk responses in the adults’ rdk production with increasing degrees of inhibiting effects of the –Rdk conditions (M-H \chi^2 = 11.98, p < 0.001) in the order of Neutral, ‘+[-VF]^2’, ‘/+h//m/’, ‘VOb+Ob’ and ‘LL’. This statistical trend seems to coincide with one of the learning patterns of the conditioning factors proposed in 6.4 that the learner may have a continuum of gradient degrees of generalizations. Even though not all the conditions stand out as prominently effective and distinctively noticeable against the rest, it probably is one reflection of how the knowledge of varying irregularity is projected in the native speakers’ mind.

We now know that LL is a significant inhibitor of productive rdk process. Vance (1979) reports the same effect in his rdk acceptability test. However, it should be recalled that this is not necessarily the case for all the subjects. First, note that there is a small proportion of subjects: 5 adults and 2 non-adults who did violate LL (see 8.2.7. for discussion). Second, the data does not account for approximately 43% of the adults (and 93% of the non-adults) who did not produce rdk at all (see 8.2.5. and 8.2.6. for further analysis). A reasonable conclusion on the –Rdk conditions at this point would be that LL, or the well-formedness constraint of the OCP-voice, did inhibit rdk to a
significant extent, but is not a categorical inhibitor of rdk for all the subjects. It is clearly not so for 5 adults who violated LL (that is about 20%) out of 26 who did apply rdk to nonsense words. It was also shown that the response patterns in reaction to the set of rdk-inhibiting conditions exhibited a significant linear decreasing trend in the number of +rdk responses along the continuum of gradient environmental effects, from the non-conditioned environment to LL, which implied that the knowledge of rdk irregularity, namely the prototypes of conditioning factors, can be treated as graded analogies, generalized abstractly relative to one another.

The following two sections aim to sharpen our focus on the subjects’ knowledge of rdk by separating the whole subjects into three types: the ‘real rdk’ subjects, the ‘pseudo-rdk’ subjects, and ‘no rdk’ subjects.

8.2.5. The ‘Real-rdk’ subjects

The ‘real rdk’ subjects refer to a particular group of subjects who produced more than one rdk response in the production test. The assumption here is that they probably possess the productive competence of rdk of a default value. In short, they have some form of rdk-producing grammar, either the developing grammars of $L_2$ or the fully-developed grammar of $L_p$. This section looks into the real rdk subjects for a more accurate picture of their rdk knowledge.

Table 10 is a break down of the number of ‘subjects’ for the three quantitatively distinct groups in terms of their grammars: whether rdk was given only in the real words (in the pre-test), in both real words and nonsense words (both the pre-test and
production test), or neither.

Table 10. Number of ‘pseudo-rdk’, ‘real rdk’ and ‘no rdk’ subjects in production
(N.B. ‘N’: non-adults, ‘A’: adults)

<table>
<thead>
<tr>
<th></th>
<th>+rdk in real words</th>
<th>no rdk in real words</th>
</tr>
</thead>
<tbody>
<tr>
<td>+rdk in nonsense words</td>
<td>32/131 (24.43%)</td>
<td>N: 6/82 (7.32%)</td>
</tr>
<tr>
<td></td>
<td>(‘real rdk’)</td>
<td>A: 26/49 (53.06%)</td>
</tr>
<tr>
<td>no rdk in nonsense</td>
<td>67/131 (51.15%)</td>
<td>32/131</td>
</tr>
<tr>
<td>words</td>
<td>(‘pseudo-rdk’)</td>
<td>N: 30/82 (36.59%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A: 2/49 (4.08%)</td>
</tr>
</tbody>
</table>

The top left cell contains the number of subjects who gave +rdk responses in both real words and nonsense words, hence the term ‘real rdk’ producers for their genuine productivity. 32 subjects out of 131 (24.43%) are of this type: 53.06% of the adults and 7.32% of the non-adults. The contrasting type is listed in the bottom left cell. They are the potential pseudo-rdk (i.e. lexically-tied rdk) subjects whose rdk is limited to the real words. There are total of 67 of 131 (51.15%) pseudo-rdk candidates (46/82 non-adults and 21/49 adults). The third group in the bottom right cell is the 32 ‘no-rdk’ subjects (24.43%) who did not give any +rdk responses in the study (30/82 non-adults and 2/49 adults). The number ‘0’ in the top right cell tells that there were no subjects who produced rdk only in the nonsense words.

We now know that the whole subject set consists of 51.15% potential pseudo-rdk subjects, 24.43% potential real rdk subjects and 24.43% no rdk subjects. The adults consist of two large groups: 53.06% real-rdk subjects and 42.86% pseudo-rdk subjects with a very few no rdk ones of 4.08%. The response patterns (% ± SD) of the 32 real rdk subjects (26 adults, 6 non-adults) are shown in Figure 6.
Figure 6. ‘Real rdk’ rates in production (of 26 adults and 6 non-adults)

<table>
<thead>
<tr>
<th>Condition</th>
<th>+Rdk responses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>10.94%</td>
</tr>
<tr>
<td>VOb+Ob</td>
<td>25.60%</td>
</tr>
<tr>
<td>+/h//m/</td>
<td>25.40%</td>
</tr>
<tr>
<td>+[-VF]2</td>
<td>34.38%</td>
</tr>
<tr>
<td>Neutral</td>
<td>39.46%</td>
</tr>
<tr>
<td>ACC</td>
<td>42.9%</td>
</tr>
<tr>
<td>N+</td>
<td>48.44%</td>
</tr>
<tr>
<td>LV+</td>
<td>56.25%</td>
</tr>
</tbody>
</table>

Their rdk profile equates to what we have seen in the previous sections. That is:

1) overall, the +Rdk environments had no effect,
2) the −Rdk environmental effect is significant against Neutral ($p < 0.01, \chi^2 = 10.76$) and +Rdk-conditioned environment ($p < 0.001, \chi^2 = 33.63$),
3) LL is the only significantly effective condition against Neutral ($p < 0.001, \chi^2 = 15.59$),
4) the two −Rdk conditions: ‘+/h//m/’ and ‘VOb+Ob’ are found relatively powerful second to LL; they are the only conditions that show no difference in effect with LL,
5) the subjects exhibited their sensitivity to the gradient effects of the −Rdk conditions.
There are, however, some new findings. Having eliminated all the subjects who gave no rdk responses in the production test, the effect of the ‘LV+’ condition (+Rdk) showed up as significant against Neutral and all the −Rdk conditions. This means that this – a long vowel immediately preceding the second element – is the only condition that makes rdk more likely. This is not what we predicted. One explanation for this finding could be that because the relevant phonological pattern is encountered only in a small group of relatively rare advanced and/or technical vocabulary items (i.e. S-J morpheme ending in a LV or /N/ + -zuru verbs) normally encountered after secondary education. Second, a new trend was found. This time, it is a highly significant positive trend for the increasing +rdk rate with the elevated effects of all the rdk conditions (M-H $\chi^2 = 41.63, p < 0.001$).

Table 11 shows the number of +rdk subjects and responses along with, mean %, SD and range.

Table 11. Production: number of ‘real rdk’ subjects and responses

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No. of subjects (%)</th>
<th>No. of +rdk responses</th>
<th>Mean % ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adults</td>
<td>6/82 (7.32%)</td>
<td>35/108</td>
<td>32.41% ± 32.47</td>
<td>11.11%–94.44%</td>
</tr>
<tr>
<td>Adults</td>
<td>26/49 (53.06%)</td>
<td>170/468</td>
<td>36.32% ± 21.33</td>
<td>5.56%–94.44%</td>
</tr>
<tr>
<td>Total</td>
<td>32/131 (24.43%)</td>
<td>205/576</td>
<td>35.59% ± 23.22</td>
<td>11.11%–94.44%</td>
</tr>
</tbody>
</table>
8.2.6. The 'Pseudo-rdk' phenomenon

The study revealed that there are a group of subjects, both adults and non-adults, who produced rdk in the real words, but not at all in the nonsense words. This could be a strong piece of evidence in favor of the initial prediction that there may be a case prior to the acquisition of rdk where all rdk instances are lexicalized knowledge rather than grammatical, and where the child could learn rdk by associative memory alone (without default). Moreover, the results provide a further and more interesting implication that this phenomenon is observed even among the adults. We have seen that there are 21 (of 49) adults in the group, which is nearly half of the adult population.

The pre-test, which preceded the production test, used four real words as second elements. Two are highly rdk-frequent words same ('shark'), kame ('turtle'), and the other two are mysteriously rdk-free words sasori ('scorpion') and sai ('rhino') that show no rdk in dictionary examples\(^\text{20}\). The type frequencies in the dictionary are as follows: 'turtle' has 10 rdk cases out of 11 compounds listed (90.91%), 'shark' 29/29 (100%), 'scorpion' 0/2 (0%), 'rhino' 0/5 (0%). These words are coupled with a set of first elements to form four novel compounds. The results are shown in Figure 7. The two dotted lines show the +rdk rates of the pseudo-rdk subjects. For the purpose of reference, those of the real-rdk subjects are also shown in two bold lines. The actual stimuli are shown along the x-axis in their order of presentation.

First of all, the results indicate that the two highly rdk-frequent second elements, i.e. *same* and *kame*, probably have their rdk counterparts stored in memory as a bound morpheme with the rdk [+voice] attached underlyingly, i.e. {-zame} and {-game} as well as their own single representations. Two facts make this interpretation probable. One, the alleged pseudo-subjects are those who did not apply rdk productively. Two, they did apply rdk to the real words but not in novel combinations that they could have never heard or created before. Of course, this does not deny the possibility that the compounds consisting of these words are stored as unanalyzed wholes like {umigame} ('sea turtle'), and so on.

The frequency factor clearly influenced all types of subjects. The high +rdk rates
of the first, second and fourth stimuli are predicted results. There is no doubt that all the subjects have heard compounds with [-zame] and [-game] before. Some might have heard of very rare compounds with [-kame], but this does not concern us here. The important thing is not that [-kame] has never been heard, but that [-zame] and [-game] have been heard. The rate for all subjects drops significantly in the third item. This is understandable partly because they have never heard [-zasori] and [-zai], but also they have rarely heard compounds involving sasori/sai. One female real-rdk subject (12;2) told the experimenter that both hasami-sasori and hasami-zasori sound strange, but either would be acceptable. In fact, it was observed that far more adults expressed uncertainty on this item than the non-adults. Then a question arises. If the real-rdk subjects are capable of productive rdk, why did they not apply more rdk to this particular item? Since the mechanism behind these seemingly indistinguishable results is assumed to be quantitatively different, it seems fairly natural that the real-rdk subjects could have shown higher rates than the pseudo-rdk subjects did. One possible explanation would be the blocking principle. Either the very morpheme {sasori} and {sai} blocked the rule application, or the pattern of similarity matched the conditioning factor ‘+[-VF]^2’. There is one source of evidence that seems to support this account. Significantly higher number of real-rdk non-adults (shown in black bold line) preferred hasami-zasori, (4 out of 6) which was an unusual choice for the rest of the subjects. It could be argued that the non-adults are not yet aware of this inhibiting prototype implied by the phonological property of sasori, and consequently let rdk apply. As a matter of fact, 5 of 6 real rdk non-adults preferred [soketa-zoso] over [soketa-soso] (+[−VF]^2: −Rdk condition) in the production test. What is interesting is that there are five +rdk responses for /soketa + soso/ of all the non-adults, and all five came from
these subjects. It may be the case that these subjects have a particular liking for this structure, or for the voicing of /s/. Nevertheless, having only six subjects in the group, this explanation is inconclusive.

Surprisingly, there are 32 (including 2 adults) ‘no (zero) rdk’ subjects who gave no rdk at all in the study. It leads to only three possible explanations. One is that all the rdk compounds they already know, regardless of their frequency, simplicity, and transparency, are probably stored in memory as unanalyzed wholes. The second is that the task was too demanding or too unfamiliar to these subjects. The third is that a test-taking behavior took over: the subjects mistook the task as a memory test or articulation test in which they committed themselves to reproduce what they had just heard as clearly and faithfully as possible, and that this resulted in no rdk responses.

In any case, it is interesting to see that the same rdk competence is achieved in two qualitatively different ways by different individuals even among the adults.

8.2.7. The violation of LL

It has been predicted that the violation of LL, although unlikely, is theoretically possible under the worst case scenario. For derivational theories, this happens before LL has been learnt, whereas OT predicts that it occurs when the immature $\mathcal{L}_2 \otimes_{[w]}$ grammar is suffering from ill-ranked UNIFORMITY[voice], which is lower ranked than desired (Weak UNIFORMITY[voice] problem) (see 4.4.4.3; 6.3.1.1.). Interestingly, as has been mentioned earlier, LL was violated by a small proportion of adults and non-adults (indicated by ‘LL2: [-zoda]’ and ‘LL3: [-detage]’ in Figure 2). This has a significant

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implication for the insights of how rdk is acquired and developed. Table 12 shows the number of responses and subjects (%) violating LL in the two stimuli: “soketa + soda” and “soketa + tetage”. LL was violated by 2 non-adults and 5 adults in a total of 7 responses. The violation rate is 1.20% for the non-adults, which is 2 responses out of 164, and 5.10% for adults, 5 of 98 total responses. The overall violation rate is 2.67%. The difference in violation rate between the adults and non-adults was found to be not significant. However, taking into account our current assumption about the types of subjects, we should be looking at the real rdk subjects rather than all subjects of whom 51.15% have no grammatical means of violating LL. The violation rates of the real rdk subjects are indicated in the table in gray.

<table>
<thead>
<tr>
<th></th>
<th>No. of responses violating LL</th>
<th>No. of subjects violating LL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-adults</strong></td>
<td>2/164 (1.20%)</td>
<td>2/82 (2.44%)</td>
</tr>
<tr>
<td>Real rdk subjects</td>
<td>2/12 (16.67%)</td>
<td>2/6 (33.33%)</td>
</tr>
<tr>
<td><strong>Adults</strong></td>
<td>5/98 (5.10%)</td>
<td>5/49 (12.24%)</td>
</tr>
<tr>
<td>Real rdk subjects</td>
<td>5/52 (9.62%)</td>
<td>5/26 (19.23%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7/262 (2.67%)</td>
<td>7/131 (5.34%)</td>
</tr>
<tr>
<td>Real rdk subjects</td>
<td>7/64 (10.94%)</td>
<td>7/32 (21.88%)</td>
</tr>
</tbody>
</table>

It was expected that, having established the target ‘full-rdk’ grammar, 100% of the adults would fail to give +rdk responses under LL condition ($= H_0$: no +rdk responses are expected under LL condition). It means that no outputs that are pronounced [soketazoda] or [soketadetage] should be observed. However, 5.10% of the adults did produce +rdk responses, which is significantly more than expected ($p = 0.0297 < 0.05$, right-sided Fisher’s Exact test). The significance becomes even greater when the real
rdk subjects are considered. What we can conclude from the data is that at least for those who seem to have some form of productive rdk grammar (which is about half of the entire subjects), LL is a categorical inhibitor of rdk for approximately 78% of the population. They must have established the grammar that disallows LL violation, i.e. either the full rdk grammar \( \mathcal{L}_p \) or the Strong UNIFORMITY[voice] grammar \( \mathcal{L}_2^\oplus[\text{si}] \). For the remaining half, though, their adherence to LL is practically unaccountable from the data and requires other means of investigation. To put it simply, if there is no rdk, there is no LL violation.

The seven subjects who violated LL need thorough investigation. Shown below in Table 13 is a full list of +rdk responses (indicated by ‘+’) given by the two non-adults and five adults. Blank cells indicate –rdk responses. Each subject is given a reference number from 1 to 7, followed by the gender F(emale)/M(ale), and the age in brackets. The first vertical column lists all 18 stimuli with tested rdk conditions in brackets, in the order of rdk environments they create: four for Neutral (condition-free, marked ‘Rdk’), eight for the –Rdk and six for the +Rdk. The rows containing LL violations are coloured in darker gray. The light-grayed rows contain + rdk responses for ‘VOb+Ob’ which will provide crucial information for the response analysis to follow. At a first glance, we can see three types of subjects. The first is no. 2 and 3 who have maximally-general rdk. The second type is no. 7 who seems to have slightly less productive rdk. These subjects tend to dislike the two adjacent obstruents (i.e. [zoda]) but do not care about the non-adjacent ones (i.e. [detage] where there is a distance between the two voiced obstruents). The third is 1, 4, 5 and 6 whose rdk seem weak and wobbly, or perhaps the responses are simply random. These subjects do not care about the two adjacent voiced obstruents but do seem to dislike the non-adjacent ones.
Table 13. Response patterns of the LL-violating subjects

<table>
<thead>
<tr>
<th>Items &amp; conditions</th>
<th>1 F (11;2)</th>
<th>2 M (12;1)</th>
<th>3 F (13;4)</th>
<th>4 M (14;11)</th>
<th>5 M (15;5)</th>
<th>6 M (30;9)</th>
<th>7 M (31;6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>soketa+teke (Rdk)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+seka</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+kotate</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+hatke</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+soda (LL)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+tetage</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>tetage+kete (VOb+Ob)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>kikezo+sokito</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+hemote (+/h//m/)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+homi</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+soso (+[-VF])</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>soketa+heheko</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>hokun+teke (/n/+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>hokun+kotate</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>tetoo+teke (LV+)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>tetoo+kotate</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>keto+teke (ACC)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>keto+kisa</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Statistically, no significant difference was found in +rdk rates between the two stimuli—“soketa + soda” (4 rdk responses out of 131) and “soketa + tetage” (3 of 131). Seemingly, the LL violation rate is independent from the length of the second element and of the location of a voiced obstruent in the second element of a compound, which accords with one of Vance’s (1979:103) findings that a voiced obstruent in the second and third mora of the second element are equally inhibiting ($p < 0.05$). However, a closer observation of the responses reveals bewildering patterns which pose a problem to our theoretical predictions. What is striking is the fact that no subjects violated LL in both stimuli. Subject number 2 (12;1), 3 (13;4) and 7 (31;6) preferred [soketa-soda] and
[soketa-detage]. Conversely, subjects 1, 4, 5 and 6 preferred [soketa-zoda] and [soketa-tetage]. This is not a theoretically feasible scenario since the grammar we have posited should not and cannot discriminate the two outputs that belong to the same type. After all, this is the whole point of positing this particular immature grammar called the Weak UNIFORMITY[voice] grammar \( L_{\mathcal{O}|w} \). Recall that this grammar has the ranking that always lets the LL-violating candidate surface, i.e. [-zoda] and [-detage]. Tableaux (144) demonstrates why [soketa-zoda] and [soketa-tetage] cannot be produced by the same grammar. The first case in (144-1) is exactly what we expect. Here, the observed response equates the desired winner.

(144) Violation of LL (‘overapplication of rdk’) in [soketa-zoda], and non-violation of LL in [soketa-tetage] of the immature \( L_{\mathcal{O}|w} \) grammar with the Weak UNIFORMITY[voice] problem.

(1) /soketa + soda/ → [soketa-zoda] (observed winner = desired winner)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [soketa + zoda]</td>
<td>*(v)</td>
<td></td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. [soketa + soda]</td>
<td>*(v)</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [soketa + zoda]</td>
<td>*(v)</td>
<td></td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(2) /soketa + tetage/ → [soketa-tetage] (observed winner ≠ desired winner)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [soketa + detage]</td>
<td>*(v)</td>
<td>*</td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>&lt;observed winner&gt;</td>
<td>*(v)</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. [soketa + tetage]</td>
<td>*(v)</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>&lt;desired winner&gt;</td>
<td>*(v)</td>
<td></td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c. [soketa + detage]</td>
<td>*(v)</td>
<td></td>
<td>**</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
If one chooses [soketazoda], the legitimate winner (c) in (144-1), the same subject should choose [soketatetage] because the desired winner in (144-2) is (c). To our surprise, the actually observed winner is (b). No constraints in the $\mathcal{L}_{2}^{\text{Ø}}$ grammar can discriminate one against the other; neither does any ranking nor re-ranking of the constraints. The inputs /soketa + p + soda/ and /soketa + p + tetage/ must always come out as [soketazoda] and [soketadetage] from the same grammar. The reversed pattern, [soketa-soda] and [soketa-detage] by subject no. 2, 3, and 7 is equally impossible. How then can we interpret this asymmetry? It is important to bear in mind that no one grammar we have posited yields such an asymmetry. As we will see, any interpretation we propose is bound to leave one of the two responses logically unaccountable by grammatical factors alone, and this forces us to attribute the mismatch to some non-grammatical (and perhaps non-linguistic) factors. We will go through several possible interpretations as to which one of the two opaque outputs is the “odd one out” in terms of grammar. However, one can always argue against the following analysis that there is a room for an alternative interpretation: the result is simply random particularly for subjects 1, 4, 5 and 6, predicting that if the same test was run on the same subjects the results would be different.

First, let us look at subject 1, 4, 5 and 6 who preferred [soketa-zoda] and [soketa-tetage] (for convenience, these subjects are referred to as ‘LL2’ hereafter for their violations in ‘-zoda’). There seems to be no better explanation but to resort to the assumption that these subjects have the Strong UNIFORMITY[voice] grammar $\mathcal{L}_{2}^{\text{Ø}}$ that singles out [soketa-zoda] as the ungrammatical output. The only motivation for this account is based on the observation that they disliked rdk in [tetage-kete] and
Chapter 8 – Results and Discussion

[kikezo-sokito], the items testing ‘VOb+Ob’. As has been predicted in chapter 4 and 6, LL and ‘VOb+Ob’ are phonologically related phenomena. Thus, any rdk patterns observed in the ‘VOb+Ob’ items can provide a clue as to what the subjects’ grammars may look like. Crucially, among our hypothetical grammar models, there is only one grammar that disallows rdk in its ‘VOb+Ob’ outputs, and that is the Strong UNIFORMITY[voice] grammar which says: “if rdk does not occur in ‘VOb+Ob’, neither should it in LL” (but not vice versa). So, the fact that LL2 subjects did not like rdk in the ‘VOb+Ob’ items justifies the view that [soketa-tetage] is the grammatical response, i.e. the legitimate output of the grammar, while [soketazoda] is the ungrammatical response, i.e. not the desired output, hence the odd one out. The list of observed and desired outputs from the \( \mathcal{L}_2^{\otimes_{[8]}} \) grammar is shown in Table 14.

Table 14. The desired and observed outputs for /yaki + soba/ and /tabi + hito/ type inputs under the immature \( \mathcal{L}_2^{\otimes_{[8]}} \) grammar (the ‘LL2’ subjects)

(N.B. \( \checkmark \): observed output = desired output, \( \times \): observed output ≠ desired output)

<table>
<thead>
<tr>
<th>Output of Grammar</th>
<th>Input type</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mathcal{L}<em>2^{\otimes</em>{[8]}} ) Strong UNIFORMITY [voice]</td>
<td></td>
</tr>
<tr>
<td>[hasi-bako]</td>
<td>/hasi + hako/</td>
</tr>
<tr>
<td>[ori-gami]</td>
<td>/ori + kami/</td>
</tr>
<tr>
<td>[yaki-soba]</td>
<td>/yaki + soba/</td>
</tr>
<tr>
<td>a. [soketa-zoda] ( \times )</td>
<td>A. /soketa + soda/</td>
</tr>
<tr>
<td>b. [soketa-tetage] ( \checkmark )</td>
<td>B. /soketa + tetage/</td>
</tr>
<tr>
<td>[tabi-hito]</td>
<td>/tabi + hito/</td>
</tr>
<tr>
<td>c. [tetage-kete] ( \checkmark )</td>
<td>C. /tetage + kete/</td>
</tr>
<tr>
<td>d. [kikezo-sokito] ( \checkmark )</td>
<td>D. /kikezo + sokito/</td>
</tr>
</tbody>
</table>

The observed responses for the /tabi + hito/ (‘VOb+Ob’) type inputs (C) and (D), are (c)

275
and (d) respectively. Only the $\mathcal{L}_{2\Theta_{\text{ps}}}$ grammar allows such outputs. Since it disallows LL violation, response (b) is a grammatical output ('✓'), but (a) [soketa-zoda] is neither grammatical ('✗') nor surface-true. Unfortunately, however, the crucial reason why LL2 subjects violated LL only in /soketa + soda/ remains largely unexplained. This is indeed a controversial case. We have to look for other sources of information for a feasible explanation. At the end of the section, we suggest one possibility that it is perhaps the individual preferences over voicing of certain obstruents.

How about subjects 2, 3 and 7 who preferred otherwise? ('LL3' hereafter for their violations in 'detage') Why did they prefer [soketa-soda] and [soketa-detage]? Two important characteristics must be pointed out about the LL3 subjects. One is that subject 2 and 3 applied rdk to every single item (subject 7 did to most of them), but mysteriously skipped only one, which is /soketa + soda/. This leads us to believe that there must be something special about this item to prevent rdk compared to its fellow stimulus /-tetage/. Probably the most intuitive account for this would be that there might have been a 'distance effect' of the voiced obstruent. Because the LL3s apply rdk almost across-the-board, one could reasonably argue that the LL3 subjects have the mature 'full rdk' $\mathcal{L}_2$ grammar (note, however, that $\mathcal{L}_{2\Theta_{\text{ps}}}$ grammar also qualifies for this. See an alternative account below). Of course, this grammar is not supposed to allow LL violation at all, but it somehow did only in /-tetage/. The discrepancy may be due to the increased distance between the initial segment and the voiced obstruent in /-tetage/ than in /-soda/, which might have weakened the effect of LL and allowed rdk only in /-tetage/. Technically, this must be attributed to the suspension of either the OCP[+voi, -son] or the UNIFORMITY[voice]-M. This effect is illustrated in (145) below.
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(145) The distance effect weakening LL in the outputs of /soketa + tetage/ input.
(‘*’ indicates suspension)

<table>
<thead>
<tr>
<th>/soketa + p + tetage/</th>
<th>OCP [+voi, -son]</th>
<th>UNIFORMITY [voice]-M</th>
<th>MAX [assoc.]</th>
<th>REALIZE-MORPHEME</th>
<th>DEP [assoc.]</th>
<th>UNIFORMITY [voice]-G</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [soketa+detage]</td>
<td>★</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>★</td>
</tr>
<tr>
<td>b. [soketa+ tetage]</td>
<td></td>
<td></td>
<td>★</td>
<td></td>
<td>★</td>
<td></td>
</tr>
<tr>
<td>c. [soketa + detage]</td>
<td>★</td>
<td></td>
<td></td>
<td></td>
<td>★</td>
<td>!</td>
</tr>
</tbody>
</table>

The distance effect, which potentially nullifies the OCP or UNIFORMITY[voice]-M penalizations (marked with ‘★’) allows (145-a) and (145-c) to surface when otherwise they are losers. As for the OCP[+voice, -son] it normally functions properly to bar output like [-zoda], in which the voiced obstruents are clearly adjacent, but somehow weakened when there is an intervening consonant as in [-tetage]. As discussed in Pierrehumbert (1992) and Frisch, Broe and Pierrehumbert (1995, 1997) on OCP-Place in Arabic, for example, the OCP effect is not confined to strictly adjacent consonants but can be extended to restrict the cooccurrence of the consonants across intervening featural specifications on the same tier (see also Yip 1989 for the OCP on nonadjacent specifications). Furthermore, the OCP is sensitive to distance effects: the separation of two consonants can weaken the OCP effect, but the effect is stronger when the consonants are perceived to be more similar. This is in accord with our observation that [-zoda] with two adjacent homorganic obstruents was less favoured than [-detage] with two non-homorganic obstruents intervened by a voiceless obstruent. This, in fact, is not entirely a new finding. It is reported by Vance (1979) (see 5.4.) that the effect of LL is decreased as the distance between the initial segment and voiced obstruent within the
second element is increased.

For the UNIFORMITY[voice]-M, it was invalidated probably because these subjects disliked the ‘gap configuration’ of the [+voice] feature in (145-c). In fact, there is some empirical evidence cross-linguistically that suggests that such gap configurations tend to be avoided (e.g. Archangeli and Pulleyblank 1994; see also Itô, Mester and Padgett 1995 for a different view).

There is an alternative explanation for the same data. It is the one that treats [soketa-soda] as the odd one out provided that the LL3 have the Weak UNIFORMITY[voice] grammar $L_2^2 \omega w$ that allows LL violation. It explains that this grammar is supposed to apply rdk to all the items including LL, but mysteriously failed in /-soda/ (marked with ‘X’). The reason is probably the lexical blocking effect in which the nonsense word /-soda/ triggered some lexical associations with the words the LL3s already know. Although there are no native words like “soda” [soda], there is some similarity with real words such as sooda [sooda] (Foreign borrowing ‘soda’) or soo-da [sooda] (‘it is so’; Y adverbial clause soo: adverbial suffix + da: copula) might have blocked rdk in this particular item. The explanation is motivated by the same fact that all LL3s favoured rdk in almost all cases including [tetage-gete] and [kikezo-zokito], the ‘VOb+Ob’ items. As briefly mentioned above, there are two types of hypothetical grammar that allow rdk in the ‘VOb+Ob’ items. One is the full rdk grammar $L_F$ that has just been proposed. The other is the Weak UNIFORMITY[voice] grammar $L_2^2 \omega w$ on which the current explanation is based. The desired and observed outputs for the given input types under the two grammars are shown in Table 15.
Table 15. The desired and observed outputs for /yaki + soba/ and /tabi + hito/ type inputs under the $L_{2\circ|w_1}$ grammar and the $L_F$ grammar (the ‘LL3’ subjects).

(N.B. ✓: observed output = desired output, ✗: observed output ≠ desired output)

| Input type         | $L_{2\circ|w_1}$            | $L_F$          |
|--------------------|------------------------------|----------------|
|                    | Weak UNIFORMITY [voice]     | ‘full rdk’     |
| /hasi + hako/      | [hasi-hako]                 | [hasi-hako]    |
| /ori + kami/       | [ori-gami]                  | [ori-gami]     |
| /yaki + soba/      | [yaki-zoba]                 | [yaki-soba]    |
| A. /soketa + soda/| a. [soketa-soda] ✗          | a. [soketa-soda] ✓|
| B. /soketa + tetage/| b. [soketa-detage] ✓       | b. [soketa-detage] ✗|
| /tabi + hito/      | [tabi-bito]                 | [tabi-bito]    |
| C. /tetage + kete/ | c. [tetage-gete] ✓         | c. [tetage-gete] ✓|
| D. /kikeye + sokito| d. [kikeye-zokito] ✓       | d. [kikeye-zokito] ✓|

Both grammars allow the observed outputs (c) and (d) (marked with ‘✓’ in the bottom two rows) for the /tabi + hito/ (‘VOB+OB’) type inputs (C) and (D). The current $L_{2\circ|w_1}$ grammar explanation critically diverges from the $L_F$ grammar on which one of (a) and (b), the two observed outputs for /yaki + soba/ type inputs (A) and (B), is regarded as undesired and ungrammatical. The $L_F$ grammar explanation is based on the prediction that the grammar does not allow LL violation, and takes the view that the distance effect makes the observed output (b) undesired and ungrammatical (‘✗’). On the contrary, the $L_{2\circ|w_1}$ grammar has the ill-ranking that permits LL violation, that makes the observed output (a) undesired and ungrammatical (‘✗’). Either way, one of (a) and (b) must always be the undesirable output for the grammar it concerns.

There are some other interesting findings. Different speakers seem to pay attention to various factors of different kinds. One is the kind of segments that
underwent rdk. Some subjects seem to prefer voicing certain consonants over others. Subject 1 and 5 seem to dislike voicing the [t] into [d]. Subject 6 and 7 tend to favour voicing of the [s], yet subjects 5, 6 and 7 disfavour voicing the [h]. These subjects' response patterns provide a good example of individual variations such as their particular preferences for consonants and various other factors. Nonetheless, the amount of data is too small to allow any conclusive account.

Two types of LL-violating subjects have been investigated. The very small numbers made the analysis more difficult and less reliable. As mentioned earlier, we cannot dismiss an alternative interpretation: the response patterns are mostly random and the subjects are inconsistent with their judgments. As far as the current interpretation is concerned, the discrepancy observed between the two LL-violating outputs casts doubt on the explanatory power of the theoretical predictions. However, two facts provided some clues on explaining the data both grammatically and extra-grammatically. One is the unexpectedly consistent relationship between the rdk patterns in LL and VOb+Ob items. The other is the near 100% rdk rates by the LL3 subjects. These facts lead us to the three inconclusive interpretations. Each one presupposes a hypothetical grammar to treat one of the two responses as ungrammatical. The biggest challenge, however, has been to motivate their ungrammaticality. The behavior of the LL2 subjects (who liked [-zoda] but surprisingly not [detage]), was left unexplained. For the LL3 case, there are two feasible interpretations. One attributes the ungrammaticality to the grammar: the distance effect that nullifies the otherwise effective constraints that bars LL violation. The other is the lexical blocking effect in association with real words. It was also suggested that individual preference of segment
voicing might have influenced the subjects’ decisions.

8.2.8. Item analysis

This final section looks at the +rdk rates of individual stimuli to demonstrate how extra-grammatical knowledge, such as lexical factors as well as conditioning factors could have affected the subjects’ productive decisions. Figure 8 below is a line plot for the number of +rdk responses (mean %) of the adults (grey line) and the non-adults (black line) for each test item plotted in the order of their +rdk rates obtained from the adults, starting with the lowest at the left. The actual combinations of words are given along the x-axis with the rdk conditions in brackets. Table 15 shows the top +rdk items. All the stimuli, 18 in total, underwent rdk at least once. It should be remembered that all the +rdk responses appeared here were produced by what have been referred to as the real rdk subjects: 26 adults and only 6 non-adults out of a total of 131. We will deal mostly with the adults rates as the non-adults’ data are statistically much less reliable and representative. Understandably, the two antagonistic groups of conditions/items, particularly the significantly effective LL and LV+, are at the opposite ends of the +rdk range, but we have some interesting mixtures of items/conditions plotted together in the mid range area. This suggests that the patterns detected by linguists, or type frequencies in dictionary examples may not always correlate with the knowledge speakers employ in such a task.
Here, we can see that the proposed conditions are not the only factors that have influenced the rdk rates. There are some significant mismatches as well as matches in +rdk rates between the items testing the same rdk condition or environments. Matches in +rdk rates are found between the test items for the following conditions: LL, ‘VOb+Ob’ (−Rdk), ‘ACC’, ‘/n/+/’, ‘LV+’ (all +Rdk). In contrast, significant disparities are observed between the two fellow items testing the ‘+VF’ condition (−Rdk) with more than 20% margin ($\chi^2 = 7.47, p < 0.05$), followed by the ‘+/h//m/’ (−Rdk) with about 18% margin ($\chi^2 = 7.18, p < 0.05$). “Soketa + heheko” (+−VF) and “soketa + hemote” (+/h//m/) were most disliked, but “soketa + soso” and “soketa + homi” were
well accepted. The collection of items testing ‘Rdk’ (condition-free, Neutral environment) has one particularly disfavoured item “soketa + hateke” \( (\chi^2 = 7.90, p < 0.05) \). All these cases involve one item behaving significantly different from its fellow stimulus, pointing towards the possibility that the subjects have relied on information other than the conditioning factors that have been posed.

One piece of such information is likely to be a phonological one. The voicing of [h] does not seem very favoured as in “soketa + heheko” \(+[-VF]^2\) and “soketa + hateke” (Rdk) in contrast with their fellow items that are without (this tendency has been already pointed out in the previous section). This is the /h/ → /h/ voicing alternation in rdk, and its peculiarity is presumably the reason why it was disfavoured.

The mismatch between “soketa + homi” and “soketa + hemote” \(+/h//m/\) is interesting as both second elements begins with /h/. Why is [soketa-bomi] moderately acceptable while [soketa-bemote] is not? Or more accurately, why does [-bomi] have a much less inhibiting effect than [-bemote]? The reason may be lexical. It partly reflects the fact that a ‘three morale’ noun of this kind is almost impossible to find in the Y vocabulary (there are a few ‘verbs’, e.g. homeru, hameru), and partly that ho- undergoes rdk more often than he- in two moraic words containing /h/ and /m/.

As a similar point, concerning the 6 non-adults, 5 of them (those who preferred +rdk in the real rdk-resisting word sasori ‘scorpion’ in the pre-test; see 8.2.6.) were most inclined to apply rdk in “soketa + soso” \(+[-VF]^2\) despite its rdk-inhibiting condition (yet the rate is not significantly high). It might be that this item was particularly salient for the subjects because, for example, it resembled some newly-acquired or frequently used/heard word, or that it matched a certain family of resembling words, for instance ‘[s—] → [z—]’, rather than the pattern [sVsV]. This is
the point Bybee and Slobin (1982) claim: speakers may capture the ‘family resemblance’ among words (drink-drank, begin-began etc.) rather than some patterns shared by words (e.g. $i \rightarrow a$ following a consonant cluster and preceding ng: drink-bring, but drank-brought). It seems fair to conclude that various saliency factors, such as frequency, lexical resemblance, phonological patterns, preference in consonants, and even non-salient factor seem to play a significant part in the subjects’ decisions over rdk. The top +rdk items (and their conditions in brackets) for both groups are shown below in Table 16.

**Table 16. Production: top +rdk items**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Overall</th>
<th>Non-adults</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>tetoo + teke (LV+)</td>
<td>soketa + soso ( [+VF])</td>
<td>tetoo + teke (LV+)</td>
</tr>
<tr>
<td></td>
<td>20/131 (15.27%)</td>
<td>5/82 (6.10%)</td>
<td>19/49 (38.78%)</td>
</tr>
<tr>
<td>2</td>
<td>soketa + seka (Rdk)</td>
<td>hokun + kotate (/N+/)</td>
<td>soketa + kotate (Rdk)</td>
</tr>
<tr>
<td></td>
<td>keto + kisa (ACC)</td>
<td>soketa + seka (Rdk)</td>
<td>soketa + seka (Rdk)</td>
</tr>
<tr>
<td></td>
<td>soketa + soso ( [+VF])</td>
<td>keto + kisa (ACC)</td>
<td>keto + kisa (ACC)</td>
</tr>
<tr>
<td></td>
<td>18/131 (13.74%)</td>
<td>3/82 (3.66%)</td>
<td>hokun + teke (/N+/)</td>
</tr>
<tr>
<td></td>
<td>15/49 (30.61%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**8.2.9. Summary: Production**

Rdk was productively applied to nonsense words at the mean rate of 35.59% by a minority of subjects (24.43%). These are 26 adults and 6 non-adults (distinguished from the rest as the ‘real rdk’ subjects). Rdk is a psychologically real rule-based process at
least for these subjects. For the rest, a total of 99, rdk appears to be generated lexically either by (1) underlying bound morpheme with rdk [+voice], or (2) unanalyzed rdk words stored as wholes. The existence of type (1) subjects confirmed the prediction of pseudo-rdk phenomenon (67 subjects including 21 adults); while type (2) supported the whole-word lexical storage hypothesis (32 subjects including 2 adults). The ‘LV+’ condition (i.e. a long vowel immediately preceding the second element encourages rdk) and ‘LL’ (i.e. a voiced obstruent in the second element block rdk) significantly influenced the +rdk rates. The significant decreasing trend in the adults’ +rdk rates with the increased inhibiting effects implied that certain conditions are projected/perceived as having gradient degrees of strength along the rdk-likelihood continuum.

Rdk seems to be acquired fairly late at around 11-12 years. The mean rdk rate before age of 13 is 2.37%, and 19.27% for 13-37 years. It is not very clear whether general cognitive development triggers the acquisition, or some academic and pedagogical factors facilitate the learning, or social interaction may help raise awareness of the phenomenon, or the cumulative effect of all these factors gives rise to the emergence of real (genuine) rdk. Judging from our finding that young pseudo-rdk speakers will split into two types of subjects: the pseudo-rdk and real (genuine) rdk adults from this age onwards, it seems reasonable to conclude that the acquisition is motivated by the impact of such changes rather than pure function of the language faculty.

At the early stage of acquisition, the overapplication of rdk (i.e. LL violation) was observed as part of maximum-generalization by two young subjects aged 12;1 and 13;4. This near across-the-board application indicates that some learners at some stage may treat rdk almost in a rule-like fashion. Study of spontaneous speech is necessary to see
whether children actually produce overgeneralization errors such as *yakizoba. LL is found to be a psychologically real constraint on rdk for 78% of the subjects with a productive rdk grammar. The overapplication of rdk was observed at a significantly higher rate than was expected. About 33% of the real rdk adults violated LL compared to about 19% of the non-adults. This is rather surprising considering that LL is known as one of the morpheme structure constraints in the Y (native) vocabulary in Japanese (Itô and Mester 1995b). It is necessary to carry out independent research on the psychological reality of OCP[+voice, –son] and the well-formedness of Y morpheme in Japanese to reinvestigate how categorical the constraint really is. This should be supplemented by a detailed statistical work on the Japanese Y lexicon to predict and measure the impact of controversial positive evidence such as jiji(i) (‘grandfather’) and baba(a) (‘grandmother’). Etymologically, these frozen forms are probably reduplications, but it is highly doubtful that actual speakers perceive them as such.

Although a larger number of stimuli testing LL would have allowed us to reach a firmer conclusion, the violation patterns have offered a valuable insight into the architecture of the subjects’ grammars. The observed patterns were less clear-cut than was expected, most likely due to various extra-grammatical factors, yet they conformed to some extent to the output patterns predicted from the hypothetical intermediate grammars. Probably the strongest supporting evidence for the multiple rdk grammar hypotheses came from the consistent correlation between the rdk patterns in LL and the ‘VOb+Ob’. There are two contrasting patterns, LL2 and LL3, coinciding with the predictions about the ‘two-sides-of-the-same-coin’ relationship between the overapplication and underapplication of rdk. The interpretation of the intriguing difference between the two violation items, and whether this is a grammatical or lexical
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matter, remains inconclusive and requires further study.

Overall, it seems that a number of intersecting factors have come into play, influencing the subjects’ decisions over rdk resulting in fairly inconsistent response patterns which is probably a true reflection of the nature of the phenomenon.

8.3. Acceptability Test

The final four sections present the results of the acceptability test which immediately followed the production test. The subjects heard the +rdk and -rdk versions of the same 18 nonsense compounds in the same order as in the production test and chose the one they liked better. The instruction was given as follows: “To finish off, you are going to hear the same words, but this time, in pairs. You have to choose the one you like. You can answer either by repeating the word or by answering ‘first’ or ‘second’”. So, for example, upon hearing “soketazoda” (short pause) “soketasoda”, one can answer “soketazoda” or “the first one”. It was stressed that they had to choose one or the other. The stimuli, 18 pairs for a total of 36, were presented orally by the experimenter, one after another, but this time, mainly for practical reasons, without using the objects. The test was intended to provide supplementary information on the knowledge of rdk, or what has been called the sounding right/wrong intuitions.

The first section, comprising three sub-sections, presents an overview of the data, the statistical analyses and comments on the possibility of random and non-random response patterns. Three sections follow to investigate the findings further by looking into different subject types, the violation of LL and item analyses to show that the
response patterns can be regarded as a mixture of grammatical, non-grammatical and miscellaneous responses based on extra-rdk factors. The final section summarizes the major findings and proposed accounts on the results of the acceptability test.

8.3.1. Overview

First of all, let us begin by looking at the overall +rdk rates. Figure 9 is a histogram for the number of +rdk responses (mean %) and SD (shown in vertical lines) of each age group. The bars indicate the level of statistical significances for numbers between the bridged age groups (for the +rdk frequency distribution for each group, see Appendix 4). This is followed by Table 17 showing the number of +rdk subjects and responses (%±SD) of the non-adults and adults (N.B. the acceptability test will be referred to as ‘perception’ to clarify the methodological – rather than conceptual – contrast with the ‘production’ task).
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Figure 9. Perception (the acceptability test): +rdk and age group

![Graph showing perception rates by age group with statistical significance markers.]

Table 17. Perception: +rdk subjects and responses, non-adults vs. adults

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No. of +rdk subjects (%)</th>
<th>No. of +rdk responses</th>
<th>(Mean % of +rdk responses ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adults</td>
<td>81 /82 (98.78%)</td>
<td>698 /1476</td>
<td>(47.29% ± 22.50)</td>
</tr>
<tr>
<td>Adults</td>
<td>45 /49 (91.84%)</td>
<td>378 /882</td>
<td>(42.86% ± 23.43)</td>
</tr>
<tr>
<td>Total</td>
<td>126 /131 (96.18%)</td>
<td>1076 /2358</td>
<td>(45.63% ± 22.86)</td>
</tr>
</tbody>
</table>

Immediately noticeable is the huge boost in the +rdk rate particularly of the non-adults when compared to their production. This, of course, is not overwhelmingly surprising when we take into the account the binomial nature of the test. A forced choice task like this is always bound to result in a certain degree of randomness. The most straightforward outcome would be a chance result of 50%, inevitably including certain wild guesses. Of course this is not denying the possibility that it could well be the real
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reflection of their passive knowledge about rdk. As far as we can tell from Figure 9 above and a scatter diagram (see Appendix 5), it is not very clear as to how random the results are. It does not appear to be completely random because for a start, four age groups, as indicated in the histogram above, show significantly higher or lower +rdk rates compared to the adjacent groups (3-4 years vs. 5 years: \(\chi^2 = 4.77\); 9 vs. 10 years: \(\chi^2 = 5.78\); 10 vs. 11 years: \(\chi^2 = 14.40\); 13-4 vs. 17-21 years: \(\chi^2 = 15.86\); 17-21 vs. 22-29 years: \(\chi^2 = 6.58\)). The first significant rise (from 3-4 to 5 years) appears difficult to explain, but the second and the third drops seem to correlate with features of the results obtained in the production test. Age 10, where the rates suddenly drop, is when the productive rdk as a group phenomenon first emerges. The low rates of the 15-16 and 17-21 years remind us of the u-shape pattern observed in the production. Yet, the data obviously requires further analysis to determine whether the overall increase in +rdk rates is a chance phenomenon or is a reflection of their knowledge or a mixture of the two. The rest of this section presents some findings which suggest that the subjects did not respond entirely by wild guesses, and that the data includes both random and non-random factors.

Figure 10 presents a clearer picture as to what extent the preference of +rdk in perception and production approximate each other. The dotted lines indicate the response patterns in the production.
8.3.1.1. The non-adults

We will begin with some statistical findings regarding the non-adults, which were virtually unobservable in the production. First, the non-adults are sensitive to the relative contrast in the rdk environments. A highly significant difference in +rdk rates
was found between the two antagonistic environments, +Rdk and −Rdk ($p < 0.001, \chi^2 = 14.35$). As a consequence, it shows a highly significant trend indicating that the number of +rdk responses increases as we move from the −Rdk, through Neutral, to the +Rdk ($M-H \chi^2 = 14.33, p < 0.001$). In addition, the LV+, one of the +Rdk conditions showed a significant positive effect, creating a positive trend within the +Rdk conditions: Neutral, ACC, /\text{n/}+, and to the LV+. ($M-H \chi^2 = 4.65, p < 0.05$). This is summarized in Table 18 below.

Table 18. Perception: the effects of rdk environments and conditions on non-adults

<table>
<thead>
<tr>
<th>No. of +rdk responses (Mean % ± SD)</th>
<th>Neutral</th>
<th>+Rdk-conditioned</th>
<th>−Rdk-conditioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 /328 (47.56% ± 30.93)</td>
<td>264 /492 (53.66% ± 29.52)</td>
<td>278 /656 (42.38% ± 24.67)</td>
<td></td>
</tr>
<tr>
<td>$p$ value</td>
<td>$p &lt; 0.001$ ($\chi^2 = 14.35$)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of +rdk responses (Mean % ± SD)</th>
<th>Neutral</th>
<th>/\text{n/}+</th>
<th>LV+</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 /328 (47.56% ± 30.93)</td>
<td>88 /164 (53.66% ± 38.31)</td>
<td>76 /164 (46.34% ± 41.41)</td>
<td>100 /164 (60.98% ± 36.87)</td>
</tr>
<tr>
<td>$p$ value</td>
<td>$p &lt; 0.05$ ($\chi^2 = 7.88$)</td>
<td></td>
<td>$p &lt; 0.05$ ($\chi^2 = 7.06$)</td>
</tr>
</tbody>
</table>

In contrast, no particular −Rdk conditions had a significant effect on the non-adults’ preference of +rdk responses. This leads us to claim that the powerful and highly productive condition of LL is not yet perceived by the age of 12. In turn, it is after 12 years that the speakers/listeners become significantly sensitive to the −Rdk conditions. This is indeed the case with the adults’ perception.
8.3.1.2. The adults

The results presented below in Table 19 confirm that the adults did not respond entirely randomly either. In fact, the perception results are quite similar to those for production pattern. First, unlike the non-adults case, there is a highly significant inhibiting effect of the \(-\text{Rdk}\) environment. The mean \text{rdk} percentage of the adults under the \(-\text{Rdk}\) environment is 31.12\%, and the non-adults is 42.38\%, and the difference is highly significant ($\chi^2 = 13.17, p < 0.001$). Table 19 compares the differences in values of the adults between the three environments. The gap between the \(-\text{Rdk}\) and Neutral is highly significant, and it is even more significant between the \(-\text{Rdk}\) and +Rdk.

Table 19. Perception: environmental effects on adults

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>+Rdk-conditioned</th>
<th>-Rdk-conditioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of +rdk responses</td>
<td>95 /196</td>
<td>161 /294</td>
<td>122 /392</td>
</tr>
<tr>
<td>(Mean % ± SD)</td>
<td>(48.47% ± 33.31)</td>
<td>(54.76% ± 32.75)</td>
<td>(31.12% ± 22.90)</td>
</tr>
<tr>
<td>$p &lt; 0.001 (\chi^2 = 16.89)$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p &lt; 0.001 (\chi^2 = 38.74)$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Understandably, it results in a highly significant trend for linear increasing number of +\text{rdk} responses and the gradient environmental effects from \(-\text{Rdk}\), Neutral to +\text{Rdk} ($M-H \chi^2 = 39.60, p < 0.001$), suggesting that the adults are more sensitive (to a highly significant extent) to the difference in environmental effects than their production results would indicate. Unlike the production, more than one condition is responsible for this inhibiting effect: the +/h//m/, VOb+Ob and LL are all significantly inhibiting.
(the latter two being ‘highly’ significant) against the Neutral environment. This is summarized in Table 20.

### Table 20. Perception: rdk-inhibiting effects on adults

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>$+[-VF]^2$</th>
<th>$+/h//m/$</th>
<th>VOb+Ob</th>
<th>LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of rdk responses</td>
<td>95 /196</td>
<td>45 /98</td>
<td>32 /98</td>
<td>21 /98</td>
<td>24 /98</td>
</tr>
<tr>
<td>Mean % ± SD</td>
<td>48.47% ± 32.84</td>
<td>45.92% ± 37.96</td>
<td>32.65% ± 34.69</td>
<td>21.43% ± 35.36</td>
<td>24.49% ± 30.83</td>
</tr>
</tbody>
</table>

$p < 0.05 (\chi^2 = 6.66)$

$p < 0.001 (\chi^2 = 20.00)$

$p < 0.01 (\chi^2 = 9.86)$

$p < 0.001 (\chi^2 = 13.16)$

$p < 0.001 (\chi^2 = 15.59)$

Naturally, there is a highly significant trend for decreasing number of rdk responses with increasing negative effect of the $-Rdk$ conditions in the order shown above (M-H $\chi^2 = 28.79, p < 0.001$).

As we have seen in Table 19, there is no overall $+Rdk$ environment effect on the adults, but there is a significant positive trend among the $+Rdk$ conditions in the order of the Neutral, ACC, /n/+, and LV+ (M-H $\chi^2 = 9.99, p < 0.01$). The LV+ condition is the single most effective one, and is highly significant in relation to the Neutral environment. Table 21 summarizes the differences in $+Rdk$ effects.
Table 21. Perception: rdk-inducing effects on adults

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>ACC</th>
<th>/N/+</th>
<th>LV+</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of rdk responses</td>
<td>95/196</td>
<td>42/98</td>
<td>51/98</td>
<td>68/98</td>
</tr>
<tr>
<td>(Mean % ± SD)</td>
<td>48.47%  (Mean % ± SD)</td>
<td>42.86%</td>
<td>52.04%</td>
<td>69.39%</td>
</tr>
<tr>
<td>± 33.31</td>
<td>± 36.80</td>
<td>± 44.44</td>
<td>± 41.85</td>
<td></td>
</tr>
</tbody>
</table>

\[ p < 0.05 \left( \chi^2 = 11.57 \right) \]

Here, the other two conditions do not show any difference compared to the Neutral (the ACC condition is even lower than Neutral). The trend is created solely by the dramatic increase from 52.04% (/N/+ to 69.39% (LV+) overriding the initial fall from 48.47% (Neutral) to 42.86% (ACC). As a minor point, the effects of the ACC and /N/+ conditions are reversed in the non-adults and adults, which is another interesting finding. For the adults, the ACC condition is not rdk-inducing. For the non-adults, the /N/+ is hardly a rdk-inducing condition.

The single significant effect of the LV+ condition on both adults and non-adults is an unexpected result since this tendency, along with the /N/+ condition, is claimed to be observed only in a small area of vocabulary involving S-J morpheme + suru (‘do’) structure (e.g. syoo-zuru ‘to produce’, kan-zuru ‘to feel’) (e.g. Martin 1952; Okumura 1980; see 3.3.2.). Since compounds with the LV+ condition are more literary and normally encountered later than those with the /N/+ condition, what makes it significantly more rdk-inducing is difficult to explain.
8.3.1.3. The ‘real rdk’, ‘pseudo-rdk’ and ‘no rdk’ subjects

In the production results, the subjects were divided into three groups based on their types of knowledge about rdk. A cross-examination of their rdk profiles in the acceptability test provides further information about the responses and the subjects. Particular attention was paid to the comparison of different types of adults to see whether the qualitative difference in knowledge was reflected in their response patterns. Table 22 compares the 26 real ‘productive’ rdk adults and 21 pseudo ‘morpheme-based’ rdk adults in the acceptability test (N.B. the two no rdk adults are not included).

Table 22. ‘Real rdk’ and ‘pseudo-rdk’ adults in perception

<table>
<thead>
<tr>
<th>Subject types (knowledge types)</th>
<th>Real rdk (productive)</th>
<th>Pseudo-rdk (morpheme-based)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of adult subjects</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>Mean +rdk rate in production (%)</td>
<td>53.06%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Mean +rdk rate in perception (%)</td>
<td>48.50%</td>
<td>37.04%</td>
</tr>
</tbody>
</table>

\[ p < 0.01 (\chi^2 = 11.20) \]

Table 22 shows that the +rdk rates of the pseudo-rdk adults were significantly lower than that of the real rdk adults, and the reason lies in the highly significant difference in the +Rdk environment \( (p < 0.001, \chi^2 = 17.26) \). What this means is that they did not produce as many rdk
responses as the real rdk adults did in the +Rdk environment. Why were the pseudo-rdk subjects not sensitive to the +Rdk environment as much as the real rdk subjects were? Recall that the pseudo-rdk subjects are those whose knowledge of rdk appears to be lexical: it was assumed to be part of a bound morpheme (e.g. {-gami} in origami) which is ready for compounding. Then, it seems natural that these subjects lack the knowledge about the +Rdk environment because two of the three conditions, namely the /N/+ and LV+, are the prototype specifications on the first element of a compound, not on the second element. Such conditions may not have significant relevance for the morphemically produced rdk which is item-specific. From these findings, it could be argued that the adults with the productive knowledge of rdk are sensitive to both +Rdk and -Rdk environments; whereas those without are sensitive only to the -Rdk environment.

As for the non-adults, most of them belonged to either pseudo-rdk or no rdk subjects in the production. For this reason, not many interesting differences were expected among the non-adults. The results of the non-adults are shown in Table 23 below.
Table 23. The 'real rdk', 'pseudo-rdk' and 'no rdk' non-adults in perception

<table>
<thead>
<tr>
<th>Subject types (knowledge types)</th>
<th>Real rdk (productive)</th>
<th>Pseudo-rdk (morpheme-based)</th>
<th>No rdk (compound-based)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of adult subjects</td>
<td>6</td>
<td>46</td>
<td>30</td>
</tr>
<tr>
<td>Mean +rdk rate in production (%)</td>
<td>32.41%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Mean +rdk rate in perception (%)</td>
<td>54.63%</td>
<td>43.84%</td>
<td>51.85%</td>
</tr>
</tbody>
</table>

$\chi^2 = 6.76$ (p < 0.05) $\chi^2 = 8.42$ (p < 0.01)

Significant environment effects

<table>
<thead>
<tr>
<th>Neutral vs. LV+</th>
</tr>
</thead>
<tbody>
<tr>
<td>+Rdk vs. −Rdk</td>
</tr>
<tr>
<td>+Rdk vs. −Rdk</td>
</tr>
</tbody>
</table>

These results are more difficult to interpret partly due to the small number of real rdk subjects. The pseudo-rdk subjects and no rdk subjects are equally sensitive to the environmental contrast, yet the real rdk subjects are free of any effect. This contradicts what we expect from these subjects who should have richer rdk knowledge than the rest. In addition, the +rdk probability of the pseudo-rdk subjects is significantly lower than the other two groups. The difference between the pseudo-rdk and no rdk subjects is particularly surprising considering the similarity rather than difference in the type of rdk knowledge they have. Note, also that the pseudo-rdk non-adults responded to the LV+ condition, which is not what we observed in the pseudo-rdk adults. It is not clear what caused the difference between the pseudo-rdk adults and non-adults.

To summarize what we have seen so far, it is confirmed that both adults and non-adults responded accordingly to the rdk environments and conditions, not entirely by chance. Overall, the sensitivity to the +Rdk ↔ Rdk environmental contrast is
common to all the subjects. The LV+ also had a major effect, yet the -Rdk conditions are what crucially separate the adults from the non-adults, which holds for both production and perception. The non-adults responded to the -Rdk - Neutral - +Rdk trend, the positive Neutral - ACC - /N/+ - LV+ trend, the LV+ effect. The adults showed a profile very similar to that in production, other than the great increase in the mean +rdk rate. The various effects are intensified in perception: the -Rdk - Neutral - +Rdk trend becomes more significant, more -Rdk conditions come into effect, and there is the Neutral - ACC - /N/+ - LV+ trend and the strong LV+ effect. Cross-comparison of the three subject groups uncovered distinct response patterns, but contrary to our expectation, the results provide little evidence on the correlation between the patterns and the difference in architecture of rdk knowledge. There are some qualitative and quantitative differences in responses among the groups. The adult pseudo-(morpheme-based) rdk subjects are lower in +rdk rates and lack sensitivity to the +Rdk conditions compared to the adult real (productive) rdk subjects who showed the widest range of sensitivity. This was attributed to the lexical nature of the pseudo-rdk knowledge. The real rdk non-adults are probably too few to exhibit any profile. It became clear that the pseudo-rdk non-adults were those who characterized the overall profile of the non-adults described above. Although the rate was significantly lower than the real rdk and no rdk non-adults for some reason, they were the ones who did prefer rdk under the LV+ condition. Compared to the adults, the non-adults patterns have left some unaccounted differences.

Having examined the statistical facts, let us turn to reexamine Figure 10, the line plot. The overall boost is most likely the logical and inevitable consequence of the alternative choice task. Between the age of 3-4 and 12, we know that the relative
positioning of the three lines, representing the three rdk environments, is not entirely arbitrary because the non-adults are already sensitive to the +Rdk ↔ -Rdk contrast as well as the gradient -Rdk - Neutral - +Rdk effect. More than half of them responded favourably to the LV+ condition. The sharp drop between the age of 9 and 10 may be due to the reaction to the knowledge about the -Rdk environment and its conditions. The LL and VOb+Ob conditions become increasingly inhibiting for all the subjects especially beyond the age of 13, seen by the red line running constantly lower than the blue and black lines. For the majority, namely the real rdk subjects, the rdk-inducing effect of the +Rdk environment and the LV+ also continue throughout. For the others, there is no such thing as the rdk-inhibiting effect. It is not a coincidence that the response patterns have more or less the same shape as the dotted lines, which represent the patterns in the production. The familiar u-shape is largely due to individual factors (the group includes three adults who chose 0% rdk in the acceptability test), but there seems to be some unaccountable tendency for these age groups to be more reluctant to accept rdk than the rest of the groups. In any case, what is important is the fact that the perception pattern and the production pattern correlate fairly well. In sum, the line plot shows that the younger group responded to the task with the knowledge of the environmental contrast as well as the rdk-favouring condition, whereas the older group did so with both the rdk-favouring and rdk-inhibiting knowledge of rdk.

As far as the non-adults are concerned, they have some partial knowledge about rdk, but are not yet ready to use it productively. That is, perception precedes production, which is a well-supported fact. The important finding is that having non-productive knowledge of rdk does not necessarily mean that the subjects do not possess the knowledge of rdk. The subjects are clearly capable of perceiving various conditions on
rdk, such as the LV+ and the +Rdk environment, in the task involving the nonsense words. This not only means that the knowledge of rdk can be stored lexically, but also that most of the subjects have some kind of schematized information in the lexicon that does not always emerge in a productive task.

Finally, not everyone chose more rdk in the acceptability test than the production test. We can see in the scatter diagram (Appendix 5) that there are five zero-rdk subjects: one female non-adult, one male and three female adults. Three of them gave no rdk in production either, but the two are real rdk subjects who did produce rdk. This may be a good example of production/perception mismatch.

The statistically significant tendencies have been brought up in support of the non-randomness of the data. However, this is not the whole story. There is a piece of compelling evidence indicating that random and/or extra-rdk factors are involved in the responses. It is the remarkable increase in the LL violation rate. It rises more than ten-fold for the adults (from 2.44% to 24.49%), and twenty-fold for the non-adults (1.20% to 42.07%). If this is a true reflection of their knowledge about rdk and the phonology of the language, then their perception must be far worse than their production. This next section investigates the source of possible randomness in the data.

### 8.3.2. The violation of LL in perception

The biggest reason to argue for the partial randomness or the “extra-rdk-ness” of the responses is the boosted +rdk rates, particularly in LL of the adults. The effect has been found highly significant, but a far greater number of +rdk responses were obtained in
highly random fashion. Table 24 shows the number of +rdk responses and subjects (and mean %) that violated LL (for the actual response data, see Appendix 6). The overall violation rate in 'responses' has risen from 2.67% in production to 35.50% in perception; violation rate in 'subjects' from 6.11% to 54.20%. More than half of the subjects did not hesitate to choose [soketa-zoda] and [soketa-detage] in the acceptability test. Note that the difference in the stimuli structure (lengths and location of a voiced obstruent) shows no statistical difference in the perceived +rdk preference of either the adults, or the non-adults.

<table>
<thead>
<tr>
<th></th>
<th>No. of responses violating LL</th>
<th>No. of subjects violating LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adults</td>
<td>69/164 (42.07%)</td>
<td>50/82 (60.98%)</td>
</tr>
<tr>
<td>Adults</td>
<td>24/98 (24.49%)</td>
<td>21/49 (42.86%)</td>
</tr>
<tr>
<td>Total</td>
<td>93/262 (35.50%)</td>
<td>71/131 (54.20%)</td>
</tr>
</tbody>
</table>

Consequently, the level of statistical significance against the null hypothesis $H_0$ became considerably greater in perception than in production for both non-adults ($\chi^2 = 87.38, p < 0.001$) and adults ($\chi^2 = 27.30, p < 0.001$). Four-times more adult subjects tolerated five-times more LL violations in perception. In this sense, the effect of LL on the adults' +rdk rate was weakened by one fifth in perception. The effect is weakened to a highly significant extent ($\chi^2 = 14.61, p < 0.001$); although it is still significantly inhibiting compared to the other conditions tested.

The question is why the adults became much more tolerant of LL violation in perception compared to the production. Does this mean that LL does not exist as a
well-formedness constraint for the majority of the adults contrary to what we have observed in production? Does this indicate that there exists a great production/perception gap for the adults? Not necessarily. It is argued that the unexpected boost in violation stems from the very nature of the task. It crucially depends on how the stimuli were perceived by each subject, and what kind of criteria was used for ‘choosing the one you like’. The upshot is that one’s response in perception equates to the one given in production if and only if the bi-morphemic input for the perceived surface form is correctly remembered and a grammatical decision is made. If not, there are only two possibilities: one, a random response; two, an ungrammatical response based on a freely self-posited underlying form. Both of these are no longer a reliable source of information on a speaker’s knowledge about rdk. The results we have may well be a mixture of the outputs of their grammars and other miscellaneous responses based on extra-rdk factors such as individual preferences.

Here is why remembering the correct/incorrect kind of input is crucial. Consider what happens when the subject hears two versions of one compound, for example, [soketatetage] and [soketadetage]. Obviously, the latter should not be chosen at all. If the correct inputs are known (remembered), the answer is straightforward. The subject re-traces the production process to reach the desired output. However, since the stimuli were not presented exactly in the same way as was done in the production test, there was no guarantee that the stimuli were perceived as compounds. On top of this, the given stimuli are totally unfamiliar words. It could have been the case that the stimuli were perceived simply as an arbitrary sequence of segments, either mono-morphemic or bi-morphemic, either Y morphemes or non-Y morphemes, etc., depending on whatever criteria come into the subject’s mind. For instance, if one perceived [soketa-detage] as a
complex Y word [soke-tade-tage], or as a single F(oreign) morpheme [soketadetage], or even as a hybrid compound of Y and M(imetic) [soketa-zoda], it would not be surprising if one placed the stimulus in one of the morpheme classes in which LL is not operative. Even though the stimuli were all accented according to the compound accentuation rule in presentation, this does not decisively eliminate the possibilities listed above. So, once such an incorrect analysis of the given surface forms has been made, then all kinds of most faithful input ↔ output mappings are possible, and [soketadetage] is in strong competition against [soketatetage], and the result will be 50/50. The decision, however, cannot always be made solely by the rdk grammar. For this reason, in order for the rdk grammar to do the evaluation, it is vital that the subject acknowledges at least that the stimuli are Y bi-morphemic compounds in which the second element contains two voiced obstruents. Furthermore, in order to achieve a more successful production-perception match, the subject has to infer that one of the [+voice] features in the given output is a result of the rdk morpheme ɸ; otherwise, again, the rdk grammar would not be of much help.

Another possibility is that one can choose on the basis of favourite consonants or sequence of consonants, as we have observed in LL-violation in production. In addition, some subjects, often under stress and time pressure, might have made a spur of the moment decision without even thinking, which could have contributed to the near-50% figure. Typically for the youngest subjects, they frequently chose an easier way of answering by referring to the given order of the stimuli (i.e. either by saying “the first/second one” or occasionally by indicating with their fingers) instead of quoting the stimulus itself. Such passive behavior could well have obscured the real motivation behind a subject’s choice.
Chapter 8 – Results and Discussion

In sum, the boost in violation is probably an inevitable consequence of such a task involving nonsense stimuli and open instruction that allows freedom of analysis of the given outputs. Rdk-oriented decisions were possible only if the correct input is known or the point of the task is clear to the subject. In this respect, the adults probably had more advantage than the non-adults. It is also a source of evidence that the data involve non-grammatical factors as well as extra-rdk factors as exemplified above.

8.3.3. Item analysis

The chapter closes with the item analysis. First, the adults and non-adults are compared to see matches and mismatches among the +rdk rates of items. This is followed by a comparison of the adults’ rates of items in production and perception. Figure 11 is a scatter plot for the mean percentages of +rdk responses (%) of the 18 items (with their rdk conditions) of the non-adults and adults in the acceptability test.
As the regression (the grey line) indicates, there are 30.44% matches between the two groups, which correspond to approximately 5 items, and the adults’ rdk rates range wider than the non-adults’. The adults’ rates range from less than 20% to the highest reaching 80%, while the non-adults range between 35% and 65%. Items above the regression are those of which rdk rates are higher for the non-adults than the adults. Those below the line are lower for the non-adults than adults. The mismatches can be
seen in the items that are scattered away from the grey line, indicating that the +rdk probability for these items are significantly biased towards either the adults or non-adults. Interestingly, both groups liked rdk in the same items, the top three from the right: “tetoo-gotate”, “tetoo-deke” (LV+) and “soketa-gotate” (Rdk = Neutral). This confirms the earlier findings that the perceived LV+ condition has an equal rdk appeal to both non-adults and adults. However, it is not very clear as to why “soketa + kotate” attracted more rdk than its fellow items and the other +Rdk-conditioned items. The top +rdk items are shown in Table 25.

Table 25. Perception: top +rdk items

<table>
<thead>
<tr>
<th>Rank</th>
<th>Overall</th>
<th>Non-adults</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>tetoo + kotate (LV+)</td>
<td>keto + kisa (ACC)</td>
<td>tetoo + kotate (LV+)</td>
</tr>
<tr>
<td></td>
<td>87/131 (66.41%)</td>
<td>53/82 (64.63%)</td>
<td>37/49 (75.51%)</td>
</tr>
<tr>
<td>2</td>
<td>soketa + kotate (Rdk)</td>
<td>soketa + kotate (Rdk)</td>
<td>tetoo + teke (LV+)</td>
</tr>
<tr>
<td></td>
<td>82/131 (62.60%)</td>
<td>52/82 (63.41%)</td>
<td>31/49 (63.27%)</td>
</tr>
<tr>
<td>3</td>
<td>tetoo + teke (LV+)</td>
<td>tetoo + kotate (LV+)</td>
<td>soketa + kotate (Rdk)</td>
</tr>
<tr>
<td></td>
<td>81/131 (61.83%)</td>
<td>tetoo + teke (LV+)</td>
<td>30/49 (61.22%)</td>
</tr>
</tbody>
</table>

It does seem that the subjects, both adults and non-adults show more liking for the voicing of the plosives /k/ and /t/ compared to the other obstruents.

The adults’ +rdk rates are divided roughly into three groups of items. At the lowest end of the x-axis is a distinct group of five items, all with the −Rdk conditions. A small group at the highest end of the axis consists of the three top +rdk items including the LV+ condition. The rest of the items fall into the largest group centered around 40-50% rate with the mixture of the conditions of moderate effects. There are two items
that show interesting disparity in the adults’ perception. “Soketa + homi” (+/h//m/) shows a fairly average rate whereas its fellow “soketa + hemote” (+/h//m/) is among the lowest rdk group. The reason is probably the lexical factor which we suggested caused the same tendency in the production.

By comparison, the non-adults have only two groups: the dominant, substantial group of items with 35-50% average rates and a small group of four items with the higher/highest rates. The outstanding popularity of “keto-gisa” among the non-adults indicates that the judgment on this particular item is not condition-driven, considering the findings that the ACC condition has no effect, and that its fellow item “keto + teke” (ACC) is not at all popular. “Keto-gisa” is salient for the non-adults probably because the voicing of the initial /k/, or the voiced obstruent /g/, is more frequent and hence more general than the other obstruents in the compounds or morphemes they already know. As has been frequently pointed out, it seems likely that the kind and frequency of consonants that undergo rdk voicing may be an important saliency factor that has an effect on the subjects’ generalizations over the +rdk tendency.

We end the section by comparing the adults’ +rdk rates of the items in the production test and the acceptability test shown in Figure 12.
Chapter 8 — Results and Discussion

Figure 12. Production vs. perception: adults’ +rdk rate of each stimulus

The regression line indicates 48% matches, about nine items. This means that there is about 50% discrepancy in the adults’ +rdk preference between when it is said and when it is heard. There are two notable tendencies. First, the sequence of two voiced obstruents is most disliked when it is heard. This is observed in the three items plotted at the bottom, i.e. [soketa-zoda] (LL), [kikezo-zokito] and [tetage-gete] (VOb+Ob).
This confirms the adults’ psychologically real tendency against the OCP violation in both production and perception. Second, the disliking for the rdk-peculiar /h/—>/b/ alternation in the production seems lost in the acceptability test. Observe that [soketa-heheko] (+[-VF]) and [soketa-hateke] (Rdk) are the worst in production, but are both among the moderately acceptable group of items in perception. This is a natural result when a subject fails to perceive /b/ in the given surface form [-beheko] and [-bateke] as the result of /h/—>/b/.

8.3.4. Summary

The first and most remarkable difference between rdk production and perception is the highly significant ‘gap’ in the subjects’ +rdk rates, indicating a considerable degree of mismatches between what were produced (on the basis of a given input) and what were chosen in perception (between two given alternative outputs). Two factors, namely non-grammatical factors (e.g. wild guesses, stress and pressure) and extra-rdk factors (e.g. incorrectly posited inputs, consonant preferences) are proposed to account for this phenomenon. However, the test did reveal some significant tendencies that seem to reflect their knowledge about rdk. Common to all the subjects are: (a) the contrast in the +Rdk and −Rdk environments, (b) the +Rdk - Neutral - −Rdk trend, (c) the Neutral – ACC – /n/+ – LV+ trend and (d) the LV+ effect. The adults’ rates doubled, yet their overall rdk profile looks like a boosted version of production, with amplified environmental effects, gaps and trends. The result is that the LV+ (+Rdk) and VOb+Ob (−Rdk) came into effect along with LL. The qualitative difference between the real rdk
and pseudo-rdk adults is clear. The pseudo-rdk adults seem to lack knowledge about the LV+ condition. On the other hand, the non-adults’ rates rose from near zero to almost 50%. The receptive rdk profile paralleled the adults’ profile other than the sensitivity to the –Rdk environment and its conditions, particularly LL and the VOb+Ob. The qualitative difference between the different types of non-adult subjects is unclear and inconclusive in the acceptability test. As far as the item analysis is concerned, the match ratio for the +rdk rates of items between the two tests is not very high: the adults vs. non-adults is about 30%, and the adults’ production vs. perception is 50%. The most and least popular +rdk items and their conditions by each subject group correlate with their overall rdk tendencies, while some saliency and non-saliency factors (e.g. disliking for the /h/ voicing, liking for the /k/ voicing, frequency of certain obstruents, phonological patterns and lexically resembling morphemes) influence their decisions too.

To conclude the chapter, the following table summarizes the data of the production test and the acceptability test.
### Table 26. Summary of the results

(N.B. Ad: Adults, Na: Non-adults, Ov: Overall)

<table>
<thead>
<tr>
<th>Production</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task</strong></td>
<td>to produce a compound from two orally given nonsense words (with or without rdk)</td>
</tr>
<tr>
<td><strong>Stimuli</strong></td>
<td>18 nonsense Y words (presented by objects)</td>
</tr>
<tr>
<td><strong>No. of subjects</strong></td>
<td>131 (49 adults, 82 non-adults)</td>
</tr>
<tr>
<td><strong>No. of +rdk responses (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Ad: 19.27%</td>
<td>Ad: 42.86%</td>
</tr>
<tr>
<td>Na: 2.37%</td>
<td>Na: 47.29%</td>
</tr>
<tr>
<td>Ov: 8.69%</td>
<td>Ov: 45.63%</td>
</tr>
<tr>
<td><strong>No. of +rdk subjects (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Ad: 53.06%</td>
<td>Ad: 91.84%</td>
</tr>
<tr>
<td>Na: 7.32%</td>
<td>Na: 98.78%</td>
</tr>
<tr>
<td>Ov: 24.43%</td>
<td>Ov: 96.18%</td>
</tr>
<tr>
<td><strong>Significant Effects</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>Ad: N ↔ Rdk +Rdk ↔ -Rdk</td>
</tr>
<tr>
<td>Na: ----</td>
<td>Na: +Rdk ↔ -Rdk -Rdk ↔ N ↔ -Rdk ('trend')</td>
</tr>
<tr>
<td><strong>+Rdk</strong></td>
<td>Ad: ---- ('Real-rdk': N ↔ LV+)</td>
</tr>
<tr>
<td>Na: ----</td>
<td>Na: N ↔ LV+ N-ACC/N+/LV+ ('trend')</td>
</tr>
<tr>
<td><strong>-Rdk</strong></td>
<td>Ad: N ↔ LL, +[VF²] ↔ LL N-+[VF²] ↔ LL+/h/+/m/-VOb-LL ('trend')</td>
</tr>
<tr>
<td>Na: ----</td>
<td>Na: ----</td>
</tr>
<tr>
<td><strong>No. of ‘Real-rdk’ subjects (responses) (%)</strong></td>
<td>Ad: 53.06% (36.32%)</td>
</tr>
<tr>
<td>Na: 7.32% (32.41%)</td>
<td>Na: (54.63%)</td>
</tr>
<tr>
<td>Ov: 24.43% (35.59%)</td>
<td>Ov: (49.65%)</td>
</tr>
<tr>
<td><strong>No. of ‘Pseudo-rdk’ subjects (responses) (%)</strong></td>
<td>Ad: 42.86% (0.00%)</td>
</tr>
<tr>
<td>Na: 56.10% (0.00%)</td>
<td>Na: (43.84%)</td>
</tr>
<tr>
<td>Ov: 51.15% (0.00%)</td>
<td>Ov: (41.71%)</td>
</tr>
</tbody>
</table>
### Chapter 8 – Results and Discussion

<table>
<thead>
<tr>
<th>No. of 'No-rdk' subjects (responses) (%)</th>
<th>Ad: 4.08% (0.00%)</th>
<th>Ad: (30.56%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na: 36.59% (0.00%)</td>
<td>Na: (51.85%)</td>
<td></td>
</tr>
<tr>
<td>Ov: 24.43% (0.00%)</td>
<td>Ov: (50.52%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of LL-violating subjects (responses) (%)</th>
<th>Ad: 12.24% (5.10%)</th>
<th>Ad: 42.86% (24.49%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na: 2.44% (1.20%)</td>
<td>Na: 60.98% (42.07%)</td>
<td></td>
</tr>
<tr>
<td>Ov: 5.34% (2.67%)</td>
<td>Ov: 54.20% (35.50%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top +rdk items</th>
<th>Ad: [tetoo-deke] ('LV+')</th>
<th>Ad: [tetoo-gotate] ('LV+')</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na: [soketa-zoso]['+$-VF']²)</td>
<td>Na: [keto-gisa] ('ACC')</td>
<td></td>
</tr>
<tr>
<td>Ov: [tetoo-deke] ('LV+')</td>
<td>Ov: [tetoo-gotate] ('LV+')</td>
<td></td>
</tr>
</tbody>
</table>
Chapter Nine

CONCLUSIONS AND IMPLIEDATIONS

Parts of the long-standing puzzle over rdk have been uncovered. There are three major findings. First, rdk is of two types: rule-based and memory-based; second, rdk in genuine sense (i.e. rule/constraint-based) is an adolescent/adult phenomenon; third, rdk is a psychologically delicate phenomenon.

During childhood, rdk predominantly stems from the underlying voice feature within either a rdk-frequent bound morpheme or a whole rdk compound stored in the lexicon. The former gives rise to a deceptively productive application of rdk to real second elements in novel compounds, but crucially not to novel second elements in novel compounds. This indicates the ‘pseudo-rdk’ vs. ‘genuine rdk’ distinction. The current study shows that genuine rdk (i.e. rule/constraint-generated rdk) is a phenomenon of half the adult population (the remaining consists of pseudo-rdk adults). Genuine rdk is acquired fairly late. The first productive use of rdk appears at around 11-12 years when the learner enters junior high school. We speculate that the changes that take place around this phase will eventually separate real (genuine) rdk adults from pseudo-rdk adults. Genuine rdk is surprisingly low in productivity (mean 35.59%). This
Chapter 9 — Conclusions

is lower than any hypothesized productive rules reported in psycholinguistic studies. This is due partly to the significant effect of the -Rdk (rdk-inhibiting) conditions, but also implies that it is perhaps a psychologically weak, unstable process. Furthermore, real rdk is proved not a unitary process, but a bundle of psychologically real processes, as predicted in the DMT framework. Speakers of modern Japanese seem to learn the process, which was once regular and productive, in diverse ways, either consciously or subconsciously, grammatically or lexically, pedagogically or naturally during adolescence or childhood, and so on. For this reason, the conventional view of rdk as a ‘productive phonological rule’ is overstated, oversimplified, misleading and begs further restatement.

We set out with a question of what constitutes the speaker’s sounding right/wrong intuition, and we now have a clearer picture. The answer seems to lie in the interface at I-language and the central system. The study suggests that what we initially called ‘intuition’ falls into three types: no rdk (purely lexical), pseudo-rdk (morphemic) and real rdk (grammatical) knowledge. No rdk intuition, as the name suggests, is perfectly clear-cut. Pseudo-rdk, the majority, is a kind of judgment based on non-grammatical, peripheral knowledge of Japanese, probably something like the relative frequency of a [voice]_p-bearing morpheme in the lexicon. For the rest, their judgments rely on the interaction of two systems as illustrated by DMT: the associations of schemata in the lexicon and the symbolic rule operation. The latter two groups of speakers could have less clear-cut, delicate and inconsistent judgments since the knowledge of rdk seems to comprise various peripheral and individual factors such as general cognition, pedagogical, academic and social experiences and even individual preference for consonant voicing, which is a new finding of the study.
The study provides support for “parametric poverty” and the two proposed settings. Random settings parallel the contrast between (a) real (genuine) rdk and no rdk/pseudo-rdk speakers, and (b) speakers who violate LL and those who do not. In OT context, this is translated as the contrast between those who have constructed the rdk ranking and those who have not, and those who obey OCP[+voice, -son]/UNIFORMITY[voice] and those who do not. Additional support is provided by dialectal and idiolectal differences in rdk. For the possibility of ‘no settings’ among the subjects is indicated by (c) the existence of a rdk-free population, perhaps due to the paucity of data, as well as (d) the widely inconsistent response data in the acceptability test. This means that in some cases there is no difference between child rdk grammar and adult rdk grammar. Half of the adult population leaves the parameter unfixed as the non-adults do. This is the very situation Smith and Cormack (2002) speculate where the parameter is still indeterminate in the adult language, resulting in delicate judgments.

There are a number of implications for the theories in which the study has been couched. For OT, the analysis on the effect of OCP[+voice, -son] suffers from an insufficient amount of data, and remains inconclusive. LL showed a significant rdk-inhibiting effect, yet it was significantly less effective than expected. The supposedly ‘categorical’ constraint on Y morpheme structure was violated by a handful of speakers including adults, but it remains unclear what motivates the violations. The data on LL violation also implicates the distance effect of nonadjacent voiced obstruents in Japanese Y morpheme. This begs a question: “what is a well-formed Y word?” It leads to one of the important objectives for further independent research: qualitative and quantitative study of the OCP[+voice, -son] effects in Japanese Y vocabulary as a part of active OT research in cross-linguistic variation in OCP effects and the nature of the
constraint in general.

Two predictions from OT received empirical support. In OT analysis LL violation could result from two sources. One is the OCP violation, and the other is UNIFORMITY[voice] unspecified for domain M(orpheme). The closer observation of violation patterns supports this prediction that the two phenomena of LL and VOb+Ob, corresponding to the strong and weak versions of LL, are phonologically related. It seems plausible that the loss of the strong version of LL (i.e. VOb+Ob) is that the phonological domain of UNIFORMITY[voice] has been split into two in the course of history of the language. In this respect, Fukazawa and Kitahara’s (2001) relativized faithfulness UNIFORMITY[voice]-M/G approach to LL seems justifiable in capturing this historical development.

Secondly, for DMT, the observed response patterns seem to be adequately captured by the theory in the interaction between the rule and patterns over exceptions in memory. In addition, the observed environmental effects seem to support the hypothesis that some of the phonological conditions and their patterns are generalized by the associative memory as graded generalizations of varying strength. If the gradient effect of the conditions is a reflection of saliency in speaker’s mind, it should correlate with the frequency factors in the input. In particular, a reason behind the prominent L.V+ effect (the rdk-inducing condition of the first element ending in a long vowel) on the real rdk population, both adults and non-adults, needs to be investigated in accordance with statistical study of the primary data and the lexicon.

Thirdly, for the theories of the mental lexicon, both the morphemic and full-representation storage hypothesis has been supported by the existence of two types of subjects: ‘real rdk’ and ‘no rdk’. A study on the third possibility: a dual-listing model
of lexical representation is needed for further understanding of the mental lexicon. In addition, the pseudo-rdk phenomenon indicates an intermediate form of representation: a rdk-bearing bound-morpheme. This unique storage/processing unit in compounding require a formal explanation in a relevant theoretical framework.

Finally, for UG theory, a deeper insight into the nature of the knowledge about rdk and syntax is possible by exploring the speaker's judgments over compounds incorporating the semantic and syntactic factors that are known to affect rdk.

Before concluding the chapter, two significant and potential drawbacks need to be addressed in the future research for firmer conclusions. A more ingenious method is called for to maximize the Y status of the stimuli, namely the nonsense second elements, so that the subjects are absolutely convinced that they are. Secondly, the semantics of compounding needs to be worked out in order to facilitate natural concept formation of modifier-head relationship, as a small group of adult informants expressed some difficulty.

To conclude, we have observed what different minds choose to do to deal with a process that no longer makes sense. For one mind, it is no more than peripheral oddities that never have either linguistic or psychological impact, and goes under the carpet altogether. A more prepared mind, however, tries to make some sense of it, and leaves room for interpretation. What is the difference? Since rdk does not seem to be acquired naturally during childhood, two possibilities remain. One is that individual differences in cognition separate the two. The other is that the nature of exposure to data determines the acquisition. In any case, the study shows the marginal psychological status of rdk as a rule-like process, and if a critical impact is not made during puberty, it would never be captured internally.
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and Row.


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University of Massachusetts, Amherst, and Rutgers University.


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Iwanami Syoten.


APPENDIX 1  Individual Answer Sheet (Japanese version)

個人別実験回答用紙

氏名： .................................................. 年生（男・女）（歳ヶ月）
生年月日： 年 月 日
調査日： 月 日 時 分 ～ 時 分
備考：

PRODUCTION

1. 勤務・選抜試験
A. めがね + バンダ
B. 1. めがね + さめ 2. くつ + かめ 3. はさみ + さそり（さい）
   4. くつ + かて 5. はさみ + かて 6. かて + かめ

2. 本試験
1. そけた + てけ 2. けと + てけ
3. ほくん + こたて
4. そけた + こたて
5. そけた + せか
6. てとう + こたて
7. てたげ + けて
8. そけた + はてけ
9. けと + きさ
10. そけた + そだ
11. そけた + てたげ
12. けぞく + そきと
13. そけた + へもて
14. そけた + へへこ
15. ほくん + てけ
16. そけた + ほみ
17. てとう + てけ
18. そけた + そそ

ACCEPTABILITY

1. めがね + さめ 2. くつ + かめ 3. はさみ + さそり（さい）
4. くつ + かて 5. はさみ + かて 6. かて + かめ

1. そけた + てけ 2. けと + てけ
3. ほくん + こたて
5. そけた + せか
7. てたげ + けて
9. けと + きさ
11. そけた + てたげ
13. そけた + へもて
15. ほくん + てけ
17. てとう + てけ

18. そけた + そそ
Individual Answer Sheet (English translation)

Individual Answer Sheet

Name: ___________________________ Grade (M • F) ( ______ years ______ months)
DOB: ______ year ______ months ______ day
Date: ______ day of week Time: ______ hour ______ min. ~ ______ hour ______ min.
Remarks:

PRODUCTION

1. Exercise: qualifying trial
   A. megane + panda ('spectacle + panda')
   B. 1. megane + same 2. kutu + kame 3. hasami + sasori (sai)
       ('spectacle' + 'shark') ('shoe' + 'turtle') ('scissors' + 'scorpion / rhino')
       4. kutu + kate 5. hasami + kate 6. kate + kame
       ('shoe') ('scissors') ('turtle')

2. Test
   1. soketa + teke 2. keto + teke
   3. hokun + kotate 4. soketa + kotate
   5. soketa + seka 6. tetoo + kotate
   7. tetage + kete 8. soketa + hateke
   9. keto + kisa 10. soketa + soda
   11. soketa + tetage 12. kikezo + sokito
   13. soketa + hemote 14. soketa + heheko
   15. hokun + teke 16. soketa + homi
   17. tetoo + teke 18. soketa + soso

ACCEPTABILITY

1. megane + same 2. kutu + kame 3. hasami + sasori (sai)
4. kutu + kate 5. hasami + kate 6. kate + kame

1. soketa + teke 2. keto + teke
3. hokun + kotate 4. soketa + kotate
5. soketa + seka 6. tetoo + kotate
7. tetage + kete 8. soketa + hateke
9. keto + kisa 10. soketa + soda
11. soketa + tetage 12. kikezo + sokito
13. soketa + hemote 14. soketa + heheko
15. hokun + teke 16. soketa + homi
17. tetoo + teke 18. soketa + soso
APPENDIX 2 Letter to Parent/Guardian (Japanese version)

平成 14 年 **月 **日
保護者各位

ロンドン大学 音声言語学部博士課程
古賀 郁人

お願い

昼食厳しく折、保護者の皆様におかれましては、ますますご健康のことと存じます。突然のお願いで大変恐縮ですが、このたび****小学校の校長先生のご許可を頂き、1年〜6 年生の児童の皆さんを対象に、下記の要領で学術調査を計画いたしました。

つきましては、夏季休業中で誠に恐れ入りますが、一人あたり 30 分程度のインタビューに参加する児童の皆さんを募集させて頂きます。この調査は、児童の知能や学力をみるものではありません。私自身の学位論文のために行うもので、調査結果は論文以外には一切使用いたしません。論文完成後、私が責任をもって廃棄いたします。この論文につきましては、学問的に日本語の研究発展に貢献できるということ以外にはございませんので、保護者の皆様のご好意に甘えるばかりではございますが、何卒ご理解ご協力を賜りますようお願い申し上げます。

記

●調査者：古賀郁人（現英国ロンド大学 音声・言語学部大学院 博士課程在学中）、男性
●目的：日本語の言葉づかいの中で、例えば「みつ（蜜）」が「はち（蜂）」と組み合わされたときに、「みつち（蜜蜂）」と読む現象は、日本語の特殊な言い表し方として知られ、世界的に広く研究されてきました。この調査では、このような言葉づかいが、日本人の子供たちにどこまで自然に（無意識）に発せられるものかどうか、実際に検証し、学位論文にしたいと考えた次第です。
●内容・方法：はじめに、5〜10 分位の簡単なおしゃべりや説明をしながらお子さんと親しい仲間づくりをします。その後、私と女性アシスタントが珍しいおもちゃを使っていろいろ質問しながら「新しい言葉」つくりを自由に楽しんでもらいます。時間は、約 30 分程度です。
●日時：夏季休業期間中（*月 **日〜*月 *日）、小学校の**室をお借りして、*日〜**日**日の間でご希望時間帯（別紙）に行いたいと思います。保護者の方のご同席を歓迎いたします。

お手数ではございますが、協力して頂ける場合には、別紙に必要事項をご記入のうえ、お子様にお持たせ下さいますようお願い申し上げます。お子様の調査に関するご意見、ご質問等ございましたら、私古賀まで直接お問い合わせ下さい。
携帯：****、自宅：****、電子メール：****
保護者同意書 (Parent Permission Form)

調査に協力いたします

*お子様のお名前 (ニックネームでも可) ___________________________ ※ ( 歳  ケ月)
※調査に必要ですのでご記入ください

*参加可能月日（曜）、時間帯（ご希望の日、時間帯をそれぞれ丸で囲んでください）：

月  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)

**(*)  **(*)  **(*)  **(*)  **(*)  **(*)  **(*)  **(*)  **(*)  **(*)  **(*)

月  *(*)  *(*)  *(*)  *(*)  *(*)  *(*)  **(*)  **(*)  **(*)  **(*)  **(*)

-------------------------------  8:30〜  9:00〜  9:30〜  10:00〜  11:00〜  11:30〜
12:00〜  13:30〜

*第2希望参加可能日時（人数調整が必要になった場合の第2希望日時を、差し支えなければご記入ください）

________月 _______日 _______曜日 時間帯：______________________________

*日時決定後の連絡先をお知らせください。 (電話、ファクス、Eメールアドレスなど)

まことに恐縮ですが、日時が追っておりますので、**, **, **日のいずれかにご協力いただける方は、**日までに、この用紙を職員室前の箱に入れてください。その後は、**日のプール受付で私古賀に直接渡してください。

お子様に調査後、お礼として、シールとノートを差し上げます。

ご協力ありがとうございます。

古賀郁人
Letter to Parent/Guardian (English translation)

Ikuto Koga, PhD student
Department of Phonetics and Linguistics
University College London

**/**/2003

To Parent or Guardian,

I would like to take this opportunity to thank you in advance for your cooperation with my PhD thesis on children, and their phonological capabilities. I have taken the liberty of requesting your child’s school’s Principal’s assistance in compiling data for my thesis. This data is to be taken from grades 1 through 6 at the elementary school level.

Though I understand it is currently the summer vacation, I would very much like your support in giving me 30 minutes of your child’s time to conduct my data research.

Let me stress that this is not an aptitude, nor intelligence test. It is simply a fact finding quiz to be used confidentially in my thesis. It will not be used for any other purpose, and will be disposed of at the completion of my report.

It will not affect your son’s/daughter’s aptitude in any way, but the result will be a better understanding of the language acquisition in children, generally. I hope that this point is enough to allow your children to be part of my data collection.

Detailed Explanation:

• Researcher: Ikuto Koga (PhD student, department of linguistics and phonetics, University College London), Male
• Purpose: In the Japanese language, there are various pronunciations (tones?) for one given combination of Japanese compound words. For example, the word hati (‘bee’), when linked to the noun mitu (‘honey’), morphs into the word mitu-bati (‘honey-bee’). How much Japanese children understand and produce this phenomenon naturally, and when adaptation of known rules occurs, is the main aim of this data collection.
• Methodology: In the first 5-10 minutes, I wish to simply talk to the children and allow them to become comfortable with me. Next, with my female assistant, and the use of unique toys created for this data research, I wish to allow the children to create new Japanese words of their own in an entertaining environment. This process will not take more than 30 minutes in total.
• Date/Time information: Please indicate on the separate sheet provided the times of
Appendix

preference for your child. Please bring them to classroom ** at his/her school. Of course, parents are also welcome to attend.

After filling in the form, please have your child pass it on to his/her teacher. If you have any queries, please do not hesitate to contact me directly.

Mobile: ****、Home: ****、E-mail: ****
Appendix

Parent/Guardian Permission Form (English translation)

I understand the research to be carried out by Ikuto Koga, and wish my child to attend.

- Child’s name (Nickname) ____________________________ ※ (Age: years months)
  (either is acceptable) ※This is vital to the research, so please be as accurate as possible

- Please indicate first preference (month, day and time)

  * (*) * (*) * (*) * (*) * (*) * (*) * (*) * (*) * (*) * (*) * (*) * (*)
  **(*) **(*) **(*) **(*) **(*) **(*) **(*) **(*) **(*) **(*)
  * (*) * (*) * (*) **(*) **(*) **(*) **(*) **(*) **(*) **(*) **(*)

  8 : 30～ 9 : 00～ 9 : 30～ 10 : 00～ 11 : 00～ 11 : 30～
  12 : 00～ 13 : 30～

- Also please indicate second preference if possible, due to possible clashes in numbers.

  Date: Day Day of week Time: ______________________

- Please provide contact information, as I will personally contact you to reconfirm date and time (contact no., alternative no., e-mail, etc.):

  

Due to time restraints for those with preferences in the first three days (**, **, **) please have your child put this form in the allocated box in front of Staff room by **. For all others, if you wish to have the form given me to me directly, I am volunteering at the school pool administration on **. I can be reached there during pool open hours.

Thank you for your cooperation. Your child will receive a sticker and notebook as a small token of my appreciation.

Ikuto Koga
**APPENDIX 3**  
Production: grouped +rdk distribution

Table for the proportion of +rdk subjects and number of +rdk responses over the corresponding total (% ± SD) are shown for each age group in the Production-test.

<table>
<thead>
<tr>
<th>Age group</th>
<th>No. of +rdk subjects (%)</th>
<th>No. of +rdk responses (Mean % of +rdk responses ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 4</td>
<td>0/14 (0.00%)</td>
<td>0/252 (0.00% ± 0.00)</td>
</tr>
<tr>
<td>5</td>
<td>0/10 (0.00%)</td>
<td>0/180 (0.00% ± 0.00)</td>
</tr>
<tr>
<td>6</td>
<td>0/9 (0.00%)</td>
<td>0/162 (0.00% ± 0.00)</td>
</tr>
<tr>
<td>7</td>
<td>1/7 (14.29%)</td>
<td>2/126 (1.59% ± 4.20)</td>
</tr>
<tr>
<td>8</td>
<td>1/6 (16.67%)</td>
<td>2/108 (1.85% ± 4.54)</td>
</tr>
<tr>
<td>9</td>
<td>0/8 (0.00%)</td>
<td>0/144 (0.00% ± 0.00)</td>
</tr>
<tr>
<td>10</td>
<td>0/11 (0.00%)</td>
<td>0/198 (0.00% ± 0.00)</td>
</tr>
<tr>
<td>11</td>
<td>1/8 (12.50%)</td>
<td>7/144 (4.86% ± 13.75)</td>
</tr>
<tr>
<td>12</td>
<td>3/9 (33.33%)</td>
<td>24/162 (14.81% ± 31.30)</td>
</tr>
<tr>
<td>13 - 14</td>
<td>7/11 (63.64%)</td>
<td>51/198 (25.76% ± 29.32)</td>
</tr>
<tr>
<td>15 - 16</td>
<td>7/11 (63.64%)</td>
<td>34/198 (17.17% ± 19.16)</td>
</tr>
<tr>
<td>17 - 21</td>
<td>4/9 (44.44%)</td>
<td>20/162 (12.35% ± 17.74)</td>
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<tr>
<td>22 - 29</td>
<td>5/11 (45.45%)</td>
<td>31/198 (15.66% ± 20.61)</td>
</tr>
<tr>
<td>30-37</td>
<td>3/8 (37.50%)</td>
<td>34/126 (26.98% ± 34.01)</td>
</tr>
<tr>
<td>Total</td>
<td>32/131 (24.42%)</td>
<td>205/2358 (8.69% ± 20.51)</td>
</tr>
<tr>
<td>Range</td>
<td>(0.00% - 63.64%)</td>
<td>(0.00% - 26.98% ± 0.00 - 34.01)</td>
</tr>
</tbody>
</table>
### APPENDIX 4  Perception: grouped +rdk distribution

Table for grouped distributions of number (%) of +rdk subjects and number (%) ± SD of +rdk responses of each age group in the Cloze-test. ‘+Rdk subjects’ are those who chose one or more +rdk responses.

<table>
<thead>
<tr>
<th>Age group</th>
<th>No. of +rdk subjects (%)</th>
<th>No. of +rdk responses (Mean % of +rdk responses ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 – 4</td>
<td>14/14 (100.00%)</td>
<td>123/252 (48.81% ± 14.97)</td>
</tr>
<tr>
<td>5</td>
<td>10/10 (100.00%)</td>
<td>107/180 (59.44% ± 15.28)</td>
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<tr>
<td>6</td>
<td>9/9 (100.00%)</td>
<td>83/162 (51.23% ± 29.63)</td>
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<tr>
<td>7</td>
<td>7/7 (100.00%)</td>
<td>57/126 (45.24% ± 25.55)</td>
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<tr>
<td>8</td>
<td>6/6 (100.00%)</td>
<td>53/108 (49.07% ± 17.00)</td>
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<td>9</td>
<td>8/8 (100.00%)</td>
<td>61/144 (42.36% ± 15.97)</td>
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<td>10</td>
<td>11/11 (100.00%)</td>
<td>59/198 (29.80% ± 21.98)</td>
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<tr>
<td>11</td>
<td>8/8 (100.00%)</td>
<td>72/144 (50.00% ± 23.38)</td>
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<tr>
<td>12</td>
<td>8/9 (88.89%)</td>
<td>83/162 (51.23% ± 31.03)</td>
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<tr>
<td>13 – 14</td>
<td>11/11 (100.00%)</td>
<td>101/198 (51.01% ± 17.00)</td>
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<tr>
<td>15 – 16</td>
<td>8/11 (72.23%)</td>
<td>58/198 (29.29% ± 25.23)</td>
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<tr>
<td>17 – 21</td>
<td>9/9 (100.00%)</td>
<td>56/162 (34.57% ± 19.20)</td>
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<tr>
<td>22 – 29</td>
<td>11/11 (100.00%)</td>
<td>95/198 (47.98% ± 14.96)</td>
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<td>30 &lt;</td>
<td>6/7 (85.71%)</td>
<td>68/126 (53.97% ± 35.09)</td>
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<tr>
<td>Total</td>
<td>126/131 (96.18%)</td>
<td>1076/2358 (45.63% ± 22.86)</td>
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<tr>
<td>Range</td>
<td>(72.23% - 100.00%)</td>
<td>(29.29% - 59.44% ± 0.00 - 35.09)</td>
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</table>
APPENDIX 5  Perception: +rdk responses of individual subjects

Age group (years)
**APPENDIX 6**  Perception: response data of LL violating subjects

M: Male  
F: Female  
•: +rendaku response  
–: -rendaku response  
• • • •: +rendaku in both the ‘VOb+Ob’ and ‘LL’ conditions  
2: when the second element of a stimuli is 2-moraic, e.g. ‘soketa + soso’  
3: when the second element of a stimuli is 3-moraic, e.g. ‘soketa + tetage’  
ACC t: ‘keto + teke’, ACC k: ‘keto + kisa’  
Rdk 2t: ‘soketa + teke’, Rdk 2s: ‘soketa + seka’  
Rdk 3k: ‘soketa + kotate’, Rdk 3h: ‘soketa + hateke’

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