University of Pennsylvania Working Papers in Linguistics

Volume 4 | Issue 2 Article 12

1-1-1997

Extraction, Gradedness, and Optimality

Frank Keller
University of Edinburgh, keller@cogsci.ed.ac.uk

Extraction, Gradedness, and Optimality

Extraction, Gradedness, and Optimality*

Frank Keller

1. Introduction

Recently, a number of researchers have proposed the use of experimental methods to elicit acceptability judgments, thus addressing the shortcomings of the conventional intuitive way of gathering linguistic data (cf. Bard et al. 1996; Cowart 1997; Schütze 1996). The use of experimental methods allows us to handle inter- and intraspeaker variation and to control for known biases on judgment behavior (cf. Schütze 1996). An experimental approach seems particularly important for the study of linguistic phenomena that involve degrees of grammaticality, and recently, several experimental investigation of gradedness have become available (cf. Cowart 1994; Keller 1996a,b; Neville et al. 1991).

The assumption that degrees of grammaticality are relevant to linguistic theory dates back to Chomsky (1964), and on an informal level, graded data are regularly used to support linguistic hypotheses (cf. Schütze 1996 for an extensive discussion). A standard case is the claim that subjacency violations result in only mild deviance, while ECP violations cause strong ungrammaticality. Belletti and Rizzi's (1988) influential study of psych-verbs builds on this assumption, making use of no less than seven levels of acceptability. However, Belletti and Rizzi's treatment of graded data is very casual and provides "no general theory of which principles *should* cause worse violations. The theory makes no prediction about the relative badness of, say, θ-Criterion versus Case Filter violations, let alone about how bad each one is in some absolute sense. The notion of relative and absolute badness of particular violations is ad hoc, and is used in just those cases where it is convenient" (Schütze 1996: 43).

This seems to be a typical case: even though the existence of graded data and their potential relevance for linguistic research seems to be generally acknowledged, hardly any effort has gone into the theoretical investigation of graded grammaticality, and none of the established grammatical frameworks offers a systematic account

*The author acknowledges the support of an ESRC Postgraduate Research Studentship and of a DAAD Doctoral Grant (Program HSP III).

of graded data. The present paper tries to address this problem by proposing a framework for graded grammaticality based on Optimality Theory, relying on the concept of ranked grammatical constraints that is independently motivated in Optimality Theory. In this model, the ranking of constraints induces a ranking of linguistic structures, and degrees of grammaticality emerge as a property of suboptimal structures.

We use this framework to develop an account for gradedness in extraction from picture NPs, showing in detail how graded data can be exploited for testing linguistic hypotheses. Our account is based the experimental data for picture NP extraction presented by Keller (1996a,b).

2. Extraction and Gradedness

Complex NPs are standardly assumed to be islands for extraction. Picture NPs, however, constitute well-known counterexamples to this assumption, as they allow for island violations in certain cases. Kluender (1992) provides a comprehensive survey of the relevant extraction data, explicitly acknowledging its graded nature, but drawing on intuitive evidence only. Keller (1996a,b) presents the results of an experimental study investigating gradedness in picture NP extraction, thus testing the theoretical claims by Kluender and others.

Kluender (1992) claims that extractability depends on the specificity of the picture NP and observes that acceptability gradually decreases from (1a) to (1e):

(1) a. Who did you see pictures of?
b. Who did you see *a* picture of?
c. Who did you see *the* picture of?
d. Who did you see *his* picture of?
e. Who did you see *John's* picture of?

Definiteness and number are among the factors that determine the specificity of an NP. Keller (1996a,b) found that the definiteness (but not the number) of the picture NP has a significant effect on acceptability. A similar specificity effect is reported by Cowart (1997: ch. 1) and Neville et al. (1991).

Extractability also depends on the semantics of the matrix verb. Aspectual class seem to be a main factor here: state verbs are more acceptable than activity verb (cf. (2a)), while for achievements and accomplishments, a verb of creation is more acceptable than a verb of destruction (cf. (2b,c)). Keller (1996a,b) reports significant acceptability differences for all pairs in (2).

(2) a. Who did you *have/analyze* a picture of?
 b. Who did you *take/destroy* a picture of?
 c. Who did you *find/lose* a picture of?

The third significant factor is the referentiality of the extracted NP. Here, the experimental data reveals the following hierarchy, with acceptability decreasing from (3a) to (3d):

(3) a. *Who* did you take a picture of?
 b. *Which man* did you take a picture of?
 c. *What* did you take a picture of?
 d. *How many men* did you take a picture of?

The account of gradedness in extraction developed in this paper is based on data from an experimental study investigating the acceptability of extraction from picture NPs (cf. Keller 1996a,b for a detailed description). This study used magnitude estimation experiments as proposed by Bard et al. (1996) to obtain graded linguistic judgments from nineteen native speakers of English. Significant effects were found for definiteness, verb class, and referentiality. All acceptability ratings given in the following sections are taken from this study and constitute the geometrical means of the responses from all subjects.

3. Gradedness and Optimality

3.1. Standard Optimality Theory

Standard Optimality Theory (OT, Grimshaw 1995; Prince and Smolensky 1993) is set up as a declarative, constraint-based grammar theory with the following basic assumptions:

(4) *Basic Assumptions of Optimality Theory*
 a. Constraints can be violated.
 b. Constraints are hierarchically ordered.
 c. In all languages, the same constraints apply. Cross-linguistic variation is due to variation in the constraint hierarchy (re-ranking of constraints).

d. A structure is grammatical if it is the optimal structure from a set candidates for a given input.

OT specifies a generation function GEN which generates a set of candidate structures (the reference set) for a given input representation. The input representation is a predicate-argument structure that has to be realized by the candidate structures (cf. section 4.1.1). An output structure is assigned to the input I as the result of an optimization process over the candidate structures for I. More precisely, the output S_{opt} for an input I is the optimal structure in the reference set $R = \text{GEN}(I)$, where optimality is defined as follows:

(5) *Optimality*

a. A structure S_i is optimal for a reference set R if, for every structure $S_j \in R$, S_i satisfies A_j better than S_j, where A_j is the highest-ranking constraint on which S_i and S_j conflict.

b. Two structures S_i and S_j conflict on a constraint A if one of them satisfies A better than the other.

c. A structure S_i satisfies a constraint A better than a structure S_j if either
   i. S_i satisfies A and S_j violates A, or
   ii. S_j violates A more often than S_i.

An optimality theoretic grammar for a given language L has to be constructed such that, for every input I, the output structure $S_{\text{opt}} \in \text{GEN}(I)$ is the grammatical realization of I in L. To achieve this, an OT grammar specifies a set of universal grammatical constraints along with a set of language-specific constraint rankings. Note that OT differs from more traditional grammar frameworks in that the grammaticality of a structure is not determined by its inherent properties, but by the set of structures it competes with.

3.2. Suboptimality and Gradedness

Standard OT assumes that all non-optimal candidates are equally ungrammatical, which leads to a binary notion of grammaticality. We propose to drop this assumption and argue for an extended version of OT that assigns each candidate a grammaticality rank relative to its competitors. In this model, the degree of grammaticality of a candidate is computed according to the standard definition of optimality in (5), i.e., based on the number and ranks of the constraints it violates.

This extension of OT can be implemented by introducing the notion of *suboptimality*, which is then used to define the relative grammaticality of a structure:

(6) *Suboptimality*
A structure S_i is suboptimal with respect to a structure S_j if there are subsets R_i and R_j of the reference set such that S_i is optimal for R_i and S_j is optimal for R_j and $R_i \subset R_j$ holds.

(7) *Grammaticality*
A structure S_i is less grammatical than a structure S_j if S_i is suboptimal with respect to S_j.

This definition generalizes the standard OT notion of grammaticality: in standard OT, grammaticality is defined as global optimality for the whole reference set, while extended OT defines grammaticality as local optimality (suboptimality) relative to a subset of the reference set. It follows that the grammaticality rank of a structure corresponds to its harmony, i.e., the optimality theoretic rank in the candidate set.

3.3. Predictions

By generalizing the predictions of standard OT, we arrive at a grammar model that makes clear empirical claims for graded data. While a standard OT grammar makes predictions of the form: structure S_i is grammatical, but structure S_j is ungrammatical, our extended version of OT predicts that structure S_i is more grammatical than structure S_j. This prediction can be tested experimentally by eliciting graded acceptability judgments: it is confirmed if the mean acceptability ranking for S_i is significantly higher than the one for S_j.

More generally, an extended OT grammar predicts a grammaticality hierarchy for the candidate structures in a given reference set. Since the grammaticality hierarchy is computed from the constraint rankings in the grammar, evidence for these rankings can be obtained by testing the predicted grammaticality hierarchy against the empirically found acceptability hierarchy for the candidate set. Hence extended OT allows to exploit evidence from suboptimal candidates: the correct prediction of the grammaticality hierarchy for a full set of suboptimal candidates constitutes considerably stronger evidence for a particular constraint ranking than the prediction of only the optimal (fully grammatical) candidate in standard OT.

Furthermore, suboptimal candidates allow the detection of hidden re-rankings: is possible that the re-ranking of a constraint does not affect the optimal candidate of a given candidate set, and hence remains invisible in standard OT (at least for this candidate set). In most cases, however, a hidden re-ranking has an impact on some of the suboptimal candidates, and hence can be detected in extended OT.

The next section gives a detailed example for the application of extended OT and the use of suboptimal candidates as linguistic evidence.

4. Optimality and Extraction

4.1. Theoretical Assumptions

4.1.1. Input

We follow Legendre et al. (1995a) in assuming that the input for constraint evaluation is specified as a predicate-argument term with scope marking (cf. Grimshaw 1995 for an alternative view). Scope is indicated by an operator (e.g., Q for questions) which is coindexed with a variable bearing the corresponding syntactic feature (e.g., [+wh] for *wh*-phrases). We adopt this input format and add the assumption that the input does not specify lexical material for predicates and arguments, but only provides category information. The lexical material, together with lexically triggered features, is filled in by the generation function GEN. This is crucial in accounting for lexical contrasts (e.g., the definiteness effect or the main verb effect in extraction), as it allows for candidates with different lexicalizations to compete, given that they share the same predicate-argument specification.[1]

The following input representation is assumed for a *wh*-question extracted from a picture NP:

[1]Note that the problem of accounting for lexical contrasts is not specific to our version of OT, but also arises in standard OT as put forward, e.g., by Grimshaw (1995). It is an instance of a more general problem: how can a structure be ungrammatical in the absence of a grammatical competitor? (Cf. Legendre et al. 1995a for a solution.)

(8) Q_i [$\mathrm{NP}_{\mathrm{Subj}}$ V [$\mathrm{NP}_{\mathrm{Pict}}$ x_i[+wh]]]

In (8), the scope of the *wh*-phrase is marked by the chain $\langle \mathrm{Q}_i, x_i[+\mathrm{wh}] \rangle$. The phrases $\mathrm{NP}_{\mathrm{Subj}}$ and $\mathrm{NP}_{\mathrm{Pict}}$ (subject and picture NP) are unspecified and have to be filled with lexical material by GEN. Note that lexical insertion can introduce additional syntactic features (e.g., [±def] to mark definiteness), thus requiring the generation of further operators to bind them.

4.1.2. Constraints

Our account is based on the cross-linguistic account of *wh*-extraction put forward by Legendre et al. (1995a,b), which we extend to accommodate extraction from picture NPs. In the following, we state the part of their constraint inventory that is relevant to our analysis.

FAITHFULNESS is a family of constraints requiring that a candidate structure realizes (parses) the input as accurately as possible. Only one faithfulness constraint is relevant here:

(9) *Faithfulness*
PARSE(F): $\langle \mathrm{Op}_i, x_i[\mathrm{F}] \rangle$ must be parsed

(9) states that an operator-variable chain in the input has to be realized by the parse, which can be achieved either by movement or by scope marker insertion. In our analysis, (9) can be instantiated as PARSE(wh) and PARSE(def).

Selection is regulated by the SUBCAT constraint, which requires that the specification in the subcategorization frame of a lexical entry has to be met by the subcategorized element:

(10) *Subcategorization*
SUBCAT: subcategorization requirements must be met

The distribution of chains is restricted by the MINIMALLINK (MINLINK) family of constraints. MINLINK requires chains to be minimal, i.e., to consist of links that cross as few barriers as possible. (Legendre et al. (1995a) assume Chomsky's (1986) definition of barrier.) A separate set of constraints exists for non-referential chains (marked [−ref]) as opposed to referential ones. MINLINK is implemented as:

(11) *Minimal Link*
a. $\textsc{Bar}^n$: a chain link must not cross n barriers
b. $\textsc{Bar}^{n[-\text{ref}]}$: a $[-\text{ref}]$ chain link must not cross n barriers

The desired minimality effect is achieved by arranging the subconstraints of MINLINK in the universal constraint subhierarchy in (12):[2] the more barriers a chain violates, the less harmonic it is. Note further that non-referential chains are universally less harmonic than referential ones.

(12) *Universal Rankings*
a. $\textsc{Bar}^n \gg \textsc{Bar}^{n-1}$
b. $\textsc{Bar}^{n[-\text{ref}]} \gg \textsc{Bar}^{n-1[-\text{ref}]}$
c. $\textsc{Bar}^{n[-\text{ref}]} \gg \textsc{Bar}^n$

Another set of constraints regulates the distribution of traces and empty operators:

(13) *Traces and Operators*
a. *t: no traces
b. *Op: no empty operators

The constraints in (13) have the effect that traces or operators reduce the harmony of a parse, and hence candidates with fewer traces or operators are preferred.

4.1.3. Rankings

Legendre et al. propose the following English-specific rankings for the constraints (9)–(11) and (13) (in addition to the universal rankings in (12)):

(14) *Rankings for English*
$\textsc{SubCat} \gg {*}\text{Q} \gg \textsc{Bar}^{3[-\text{ref}]} \gg \textsc{Parse}(+\text{wh}) \gg \textsc{Bar}^{2[-\text{ref}]} \gg \textsc{Bar}^{1[-\text{ref}]} \gg \textsc{Bar}^4 \gg \textsc{Bar}^3 \gg \textsc{Bar}^2 \gg \textsc{Bar}^1 \gg {*}\text{t}$

Our account leaves this hierarchy intact, but adds some new rankings to locate additional constraints.

[2] $A_i \gg A_j$ indicates that the constraint A_i is ranked higher than the constraint A_j.

4.2. Extraction from Picture NPs

4.2.1. Definiteness

The experimental data presented by Keller (1996a,b) shows that extraction from indefinite picture NPs is significantly more acceptable than from definite ones, cf. the ratings in (15).[3]

(15) a. Which man did you take a picture of? 49.39
b. Which man did you take the picture of? 43.74

To account for this definiteness effect, we propose to integrate Diesing's (1992) analysis of indefinite NPs into the account of *wh*-extraction by Legendre et al. (1995a,b). Diesing's treatment of indefinites is part of a more general theory of the syntax-semantics interface, in which the mapping between scoped syntactic structures (LF representations) and quantified semantic representations is reduced to the following simple mechanism:

(16) *Mapping Hypothesis*
Material from VP is mapped into the nuclear scope.
Material from IP is mapped into a restrictive clause.
(Diesing 1992: 15)

In Diesing's approach, presuppositional material has to be mapped into the restrictive clause of a quantifier to be interpreted correctly. Definite NPs are presuppositional, and hence have to undergo this mapping. Diesing assumes that Quantifier Raising (QR) applies at the level of LF and adjoins definite object NPs to IP, from where they are then mapped into the restrictor via (16). Indefinite NPs, on the other hand, are ambiguous between a presuppositional and an existential reading: presuppositional indefinite objects are raised to IP (just like definites), whereas existential ones stay within VP and are mapped into the nuclear scope to receive an existential closure interpretation.

We propose to recast the basic insight of Diesing's approach to scope assignment in OT. As OT is a monostratal framework that does not assume the level of LF, we cannot stipulate that NPs are adjoined to VP or IP via QR. Instead, we assume a mapping operator M that correlates with a feature [±def]. This feature instantiates

[3]The numbers we give are experimentally determined mean acceptability ratings, cf. section 2.

the PARSE(F) constraint (cf. (9)), requiring the chain $\langle M_i, x_i[\pm\text{def}]\rangle$ to be parsed. We stipulate that M has to adjoin to IP for [+def] NPs, and to VP for [−def] ones, thus marking the scope of the NP in accordance with (16). Parsing can be achieved either by moving the NP to scope position (which is a crosslinguistic option, cf. section 4.3.2), or by leaving the NP in situ and realizing M as an empty operator. The former option results in a chain $\langle NP_i, t_i\rangle$ and violates *t, the latter produces a chain $\langle M_i, NP_i\rangle$ and violates *M, an instantiation of *Op. Furthermore, we have to assume that the Mapping Hypothesis applies to material chain-linked to VP or IP, instead of applying to material within VP or IP.

As an example consider tableau 1, which gives the candidate set for a picture NP in a non-extraction configuration.[4] (Our tableaux are set up such the rank of the constraints decreases from left to right, while the harmony of the candidates decreases from top to bottom.) Note that both candidates in tableau 1 have the same constraint profile, violating *M and BAR[1] (as the chain $\langle M_i, NP_i\rangle$ crosses the barrier VP). In extended OT, this predicts that both candidates are equally acceptable (which is trivially true).

	$[NP_{Subj}$ V $[NP_{Pict}$ NP]]	B 1	*t	*M
a.	$[_{IP}$ you took $[_{VP}$ M_j $[_{VP}$ $[_{NP_j[-def]}$ a picture of Mary]]]]	*		*
b.	$[_{IP}$ M_j $[_{IP}$ you took $[_{VP}$ $[_{NP_j[+def]}$ the picture of Mary]]]]	*		*

Tableau 1: Unextracted definite vs. indefinite picture NPs

Now consider tableau 2, which gives the candidate set for extraction from a picture NP, as generated from the input in (8). We assume the ranking *t $\gg$ *M, thus predicting that the insertion of an empty operator M is favored over movement. Hence, the [±def] NP stays in situ, which correctly captures the facts for English (but cf. 4.3.2 for crosslinguistic data). Furthermore, tableau 2 relies on the assumption that M turns the projection it adjoins to into a barrier. (Diesing (1992: 130) makes a similar assumption in postulating that adjunction to IP creates a barrier at LF.) For candidate (b), this

[4]As indefinite NPs are ambiguous between a presuppositional and an existential reading, they can be marked [+def] or [−def]. Presuppositional indefinites are ignored here, as they behave analogously to definites.

means that IP is a barrier for the chain ⟨*which man*$_i$, t_i⟩, thus incurring a violation of BAR^2. In candidate (a), however, M adjoins to VP, which is an inherent barrier anyway, and hence only a violation of BAR^1 ensues. The resulting constraint profile predicts that extraction from indefinite picture NPs is more grammatical than from definite ones, which is in line with the data in (15).

	Q_i [NP_{Subj} V [NP_{Pict} x_i[+wh]]]	BAR 2	BAR 1	*t	*M
a.	[$_{CP}$ which man$_i$ did [$_{IP}$ you [$_{VP}$ M_j [$_{VP}$ take [$_{NP_j[-def]}$ a picture of t_i[+wh]]]]]]		**	*	*
b.	[$_{CP}$ which man$_i$ did [$_{IP}$ M_j [$_{IP}$ you [$_{VP}$ take [$_{NP_j[+def]}$ the picture of t_i[+wh]]]]]]	*	*	*	*

Tableau 2: Extraction from definite vs. indefinite picture NPs

4.2.2. Verb Class

The experimental findings of Keller (1996a,b) showed that extraction from [+creation] verbs like *take* is significantly more acceptable than from [−creation] verbs like *destroy*. In addition, it was found that the effect from verb class decreases acceptability more than the definiteness effect, cf. the following ratings:

(17) a. Which man did you take a picture of? 49.39
b. Which man did you take the picture of? 43.74
c. Which man did you destroy a picture of? 41.01
d. Which man did you destroy the picture of? 36.94

To account for the effect from verb class, we follow Diesing (1992: 120ff) in assuming that a [−creation] verb like *destroy* selects a presuppositional reading for its object NP. In OT, this can be implemented by assuming that a [−creation] verb subcategorizes for a [+def] NP. The feature [+def] has to be linked to IP via chain formation, resulting in the desired presuppositional interpretation of the NP. It follows that the SUBCAT constraint is violated in (17c), as the object NP does not meet the [+def] specification. If we now assume that SUBCAT outranks BAR^2, then the contrast between (17b) and (17c) is explained.

However, (17d) is less acceptable than (17c), even though (17d) contains a [+def] NP, and hence does not violate SUBCAT. This contrast seems to be due to extraction: the unextracted version of (17d) is fully acceptable. Hence, in analogy to the contrast in (15), the decrease in acceptability in (17d) seems to be caused by the extraction chain $\langle \textit{which man}_i, t_i \rangle$, which we assume to incur an additional barrier violation in (17c,d). It is unclear how this additional violation comes about. A possible explanation is that barrierhood correlates with feature selection: *destroy* selects the feature [+def] for its object NP, and hence turns it into a barrier for $\langle \textit{which man}_i, t_i \rangle$. Then (17c) violates BAR^2, while (17d) violates BAR^3, which we assume to outrank SUBCAT. However, this assumption contradicts Legendre et al.'s ranking of SUBCAT in (14). This can be resolved by stipulating different subconstraints of SUBCAT for feature selection (as in our case) as opposed to category selection (as in Legendre et al.'s case). It is intuitively plausible that violations of feature selection (violations of SUBCAT(F)) are less serious and cause a smaller degree of ungrammaticality.

Our overall ranking then yields the candidate set in tableau 3, which correctly reflects the ranking of the examples in (17) (violations of *t and *M are irrelevant and thus omitted).

	Q_i [NP_{Subj} V [NP_{Pict} x_i[+wh]]]	B 3	SC F	BAR 2	BAR 1
a.	[$_{CP}$ which man$_i$ did [$_{IP}$ you [$_{VP}$ M_j [$_{VP}$ take [$_{NP_j[-def]}$ a picture of t_i[+wh]]]]]]				**
b.	[$_{CP}$ which man$_i$ did [$_{IP}$ M_j [$_{IP}$ you [$_{VP}$ take [$_{NP_j[+def]}$ the picture of t_i[+wh]]]]]]			*	*
c.	[$_{CP}$ which man$_i$ did [$_{IP}$ you [$_{VP}$ M_j [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[-def]}$ a picture of t_i[+wh]]]]]]		*	*	*
d.	[$_{CP}$ which man$_i$ did [$_{IP}$ M_j [$_{IP}$ you [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[+def]}$ the picture of t_i[+wh]]]]]]	*			*

Tableau 3: Interaction of definiteness and verb class

4.2.3. Referentiality

The experimental data showed that extraction from picture NPs is significantly more acceptable if the extracted *wh*-phrase is referential (such as *which man*), rather than non-referential (such as *how many men*):

(18)	a.	Which man did you take a picture of?	49.39
	b.	How many men did you take a picture of?	38.02

This acceptability difference follows directly from Legendre et al.'s hypothesis that non-referential chains are universally less harmonic than referential ones (cf. (12c)). If we now extend the candidate set in tableau 3 to contain both referential and non-referential picture NPs and adopt Legendre et al.'s English-specific rankings for $\text{BAR}^{n[-\text{ref}]}$ and BAR^{n} in (14), then we obtain the constraint profile in tableau 4. The grammaticality hierarchy predicted by this profile can be tested against the experimental data of Keller (1996a,b) in (19).

(19)	a.	Which man did you take a picture of?	49.39
	b.	Which man did you take the picture of?	43.74
	c.	Which man did you destroy a picture of?	41.01
	d.	Which man did you destroy the picture of?	36.94
	e.	How many men did you take a picture of?	38.02
	f.	How many men did you take the picture of?	30.56
	g.	How many men did you destroy a picture of?	20.15
	h.	How many men did you destroy the picture of?	18.54

Note that the acceptability hierarchy in (19) reflects the grammaticality hierarchy in tableau 4 almost perfectly (apart from the candidates (d) and (e), which are in the wrong order). This constitutes strong evidence for the rankings that we have assumed in sections 4.2.1 and 4.2.2, as well as for Legendre et al.'s rankings in (12) and (14).

4.3. Predictions

4.3.1. Stage/Individual-Level Predicates

So far we have only considered a narrow range of data, viz., extraction from picture NPs (objects NPs). This section contains some proposals on how our representational version of the Mapping hypothesis (cf. (16)) can be used to deal with other data covered by Diesing (1992). She makes the following observation as to the behavior of indefinite subjects:

	Q$_i$ [NP$_{Subj}$ V [NP$_{Pict}$ x_i[+wh]]]	BAR$^{[-ref]}$ 3	BAR$^{[-ref]}$ 2	BAR$^{[-ref]}$ 1	B 3	SC F	BAR 2	BAR 1
a.	[$_{CP}$ which man$_i$ did [$_{IP}$ you [$_{VP}$ M$_j$ [$_{VP}$ take [$_{NP_j[-def]}$ a picture of t$_i$[+wh]]]]]]							**
b.	[$_{CP}$ which man$_i$ did [$_{IP}$ M$_j$ [$_{IP}$ you [$_{VP}$ take [$_{NP_j[+def]}$ the picture of t$_i$[+wh]]]]]]						*	*
c.	[$_{CP}$ which man$_i$ did [$_{IP}$ you [$_{VP}$ M$_j$ [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[-def]}$ a picture of t$_i$[+wh]]]]]]					*	*	*
d.	[$_{CP}$ which man$_i$ did [$_{IP}$ M$_j$ [$_{IP}$ you [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[+def]}$ the picture of t$_i$[+wh]]]]]]				*			*
e.	[$_{CP}$ how many men$_i$ did [$_{IP}$ you [$_{VP}$ M$_j$ [$_{VP}$ take [$_{NP_j[-def]}$ a picture of t$_i$[+wh][−ref]]]]]]			*				*
f.	[$_{CP}$ how many men$_i$ did [$_{IP}$ M$_j$ [$_{IP}$ you [$_{VP}$ take [$_{NP_j[+def]}$ the picture of t$_i$[+wh][−ref]]]]]]		*					*
g.	[$_{CP}$ how many men$_i$ did [$_{IP}$ you [$_{VP}$ M$_j$ [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[-def]}$ a picture of t$_i$[+wh][−ref]]]]]]		*			*		*
h.	[$_{CP}$ how many men$_i$ did [$_{IP}$ M$_j$ [$_{IP}$ you [$_{VP}$ destroy$_{[+def]}$ [$_{NP_j[+def]}$ the picture of t$_i$[+wh][−ref]]]]]]	*						*

Tableau 4: Interaction of definiteness, verb class, and referentiality

(20) *Stage-Individual-Level Distinction*
In a logical representation, bare plural subjects of stage-level predicates can appear either in the nuclear scope [...] or the restrictive clause [...]. Bare plural subjects of individual-level predicates can only appear in the restrictive clause.
(Diesing 1992: 19)

Diesing assumes that stage-level (SL) and individual-level (IL) predicates differ syntactically in that their subjects are base-generated in Spec-VP and Spec-IP, respectively. The subject of an SL predicate moves to Spec-IP at S-structure, but it is optionally reconstructed to its base position in Spec-VP via LF-Lowering. By virtue of the Mapping Hypothesis, she then predicts that SL predicates, but not IL predicates, are ambiguous, as stated in (20).

A relevant example is the contrast in (21), which involves the SL predicate *available* and the IL predicate *intelligent*.

(21) a. Firemen are available.
b. Firemen are intelligent.

(21a) is ambiguous between an existential and a generic (presuppositional) reading, while (21b) only has the generic reading.

Under the assumptions we made about the representation of indefinites in OT (cf. section 4.2.1), this contrast follows straightforwardly. Consider the constraint profile for (21) in tableau 5. Here, as the subject of *available* is base generated in Spec-VP, well-formed chains can be generated for candidates (a) and (b), viz., $\langle M_j, NP_j, t_j \rangle$ and $\langle NP_j, M_j, t_j \rangle$, thus predicting that the indefinite can have both readings. For *intelligent*, however, the subject is base-generated in Spec-IP, resulting in the chains $\langle M_j, NP_j \rangle$ and $\langle NP_j, M_j \rangle$. The latter chain is ill-formed and hence violates PARSE(def), which we assume to outrank *t.

	$[NP_{\text{Subj}}$ V $AP_{\text{Pred}}]$	P def	*t	*M
a.	$[_{IP}$ M_j $[_{IP}$ $[_{NP_j[+def]}$ firemen] are $[_{VP}$ intelligent]]]			*
b.	$[_{IP}$ M_j $[_{IP}$ $[_{NP_j[+def]}$ firemen] are $[_{VP}$ t_j available]]]		*	*
c.	$[_{IP}$ $[_{NP_j[-def]}$ firemen] are $[_{VP}$ M_j $[_{VP}$ t_j available]]]		*	*
d.	$[_{IP}$ $[_{NP_j[-def]}$ firemen] are $[_{VP}$ M_j $[_{VP}$ intelligent]]]	*		*

Tableau 5: Stage-level vs. individual-level predicates

Hence tableau 5 correctly predicts the reading represented by candidate (d) to be dispreferred, and thus explains the contrast in (21).[5] Note that this explanation is arrived at without positing a separate level of LF along with additional mechanism like Quantifier Raising and LF-Lowering. We simply stipulate a mapping operator M, which is governed by independently motivated constraints on operators and chains in OT and allows the Mapping Hypothesis to apply on surface representations.

4.3.2. Crosslinguistic Data

OT is based on the crucial assumption that crosslinguistic variation is due to variation in the constraint hierarchy. Hence, if the proposed

[5]The (d) reading is not excluded completely, as Diesing (1992) points out with reference to focus data.

analysis is correct, we expect the same constraints that we have stipulated for English to hold for other languages, modulo potential constraint re-rankings.

Indeed, this seems to be the case. Consider the following German data presented by Diesing (1992: 37f):

(22) a. … weil Professoren ja doch verfügbar sind.
since professors 'indeed' available are
'… since (in general) professors are available.'
b. … weil ja doch Professoren verfügbar sind.
since 'indeed' professors available are
'… since there are professors are available.'

(23) a. … weil Wildschweine ja doch intelligent sind.
since wild boars 'indeed' intelligent are
'… since (in general) wild boars are intelligent.'
b. *? … weil ja doch Wildschweine intelligent sind.
since 'indeed' wild boars available are

Under the assumption that the particle *ja doch* marks the VP boundary, these data show that indefinite subject NPs in German move to IP to receive a generic interpretation (as in (22a), (23a)), while they stay within VP to receive an existential interpretation (which is possible for SL-predicates as in (22a), but not for IL-predicates as in (23a)). In English, in contrast, no overt movement (lowering) takes place, but a chain link is established to an empty operator in IP and VP, respectively.

This crosslinguistic fact can be accounted for straightforwardly by assuming that in German, the ranking *M $\gg$ *t holds, while English has the ranking *t $\gg$ *M. This entails that German prefers movement (violating *t), whereas English prefers inserting an empty operator (violating *M). Under this assumption, we get the candidates in tableau 6 for the examples in (22).

5. Conclusion

This paper proposed an extended version of Optimality Theory as a model for graded grammaticality, based on the assumption that the harmony of a structure corresponds to its grammaticality. We showed that this framework can be used to account for gradedness in extraction from picture NPs based on experimental data. Our analysis explained the graded nature of extraction in terms of two constraints:

	$[\mathrm{NP_{Subj}}$ V $\mathrm{AP_{Pred}}]$	P def	*M	*t
a.	$[_{\mathrm{IP}}\ [_{\mathrm{NP}_j[+\mathrm{def}]}$ Professoren] $[_{\mathrm{VP}}\ t_j$ verfügbar sind]]			*
b.	$[_{\mathrm{IP}}\ [_{\mathrm{VP}}\ [_{\mathrm{NP}_j[-\mathrm{def}]}$ Professoren] $[_{\mathrm{VP}}\ t_j$ verfügbar sind]]]			*
c.	$[_{\mathrm{IP}}\ M_j\ [_{\mathrm{VP}}\ [_{\mathrm{NP}_j[+\mathrm{def}]}$ Professoren] verfügbar sind]]		*	
d.	$[_{\mathrm{IP}}\ [_{\mathrm{VP}}\ M_j\ [_{\mathrm{NP}_j[+\mathrm{def}]}$ Professoren] verfügbar sind]]		*	

Tableau 6: Movement vs. empty operator insertion in German

MINLINK and SUBCAT. Graded effects from violations of subjacency (MINLINK) are well known from the literature (cf. section 1). Graded effects from violations of selectional constraints (SUBCAT) are less well studied, but Chomsky (1965: ch. 4) proposes a framework where the degree of grammaticality of a structure depends on the type of selectional specification violated. Chomsky's approach is similar to our stipulation that the violation of a selectional feature like [+def] is less serious than the violation of a category specification in SUBCAT (cf. section 4.2.2).

Certainly, the results presented here are preliminary, and a broader range of linguistic phenomena has to be studied to show the viability of our approach. It would be particularly interesting to complement the judgment data used here by other types of experimental data, using paradigms such as event-related potentials (cf. Neville et al. 1991) and sentence matching (cf. Freedman and Forster 1985), which have been claimed to be relevant to grammaticality.

References

Bard, Ellen G., Dan Robertson, and Antonella Sorace (1996). "Magnitude Estimation of Linguistic Acceptability." *Language* 72:32–68.

Belletti, Adriana and Luigi Rizzi (1988). "Psych-Verbs and θ-Theory." *Natural Language and Linguistic Theory* 6:291–352.

Chomsky, Noam (1964). "Degrees of Grammaticalness." In Jerry A. Fodor and Jerrold J. Katz, eds., *The Structure of Language: Readings in the Philosophy of Language*, 384–389. Prentice-Hall.

Chomsky, Noam (1965). *Aspects of the Theory of Syntax*. MIT Press.

Chomsky, Noam (1986). *Barriers*. Cambridge, MA: MIT Press.

Cowart, Wayne (1994). "Anchoring and Grammar Effects in Judgments of

Sentence Acceptability." *Perceptual and Motor Skills* 79:1171–82.

Cowart, Wayne (1997). *Experimental Syntax. Applying Objective Methods to Sentence Judgments*. Thousand Oaks, CA: Sage Publications.

Diesing, Molly (1992). *Indefinites*. Cambridge, MA: MIT Press.

Freedman, Sandra E. and Kenneth I. Forster (1985). "The Psychological Status of Overgenerated Sentences." *Cognition* 19:101–131.

Grimshaw, Jane (1995). "Projection, Heads, and Optimality." *Linguistic Inquiry*, to appear.

Keller, Frank (1996a). *Extraction from Complex Noun Phrases. A Case Study in Graded Grammaticality*. Master's thesis, Institute for Computational Linguistics, University of Stuttgart.

Keller, Frank (1996b). "How Do Humans Deal with Ungrammatical Input? Experimental Evidence and Computational Modelling." In Dafydd Gibbon, ed., *Natural Language Processing and Speech Technology*, 27–34. Berlin: Mouton de Gruyter.

Kluender, Robert (1992). "Deriving Island Constraints from Principles of Predication." In Helen Goodluck and Michael Rochemont, eds., *Island Constraints: Theory, Acquisition and Processing*, 223–258. Dordrecht: Kluwer.

Legendre, Géraldine, Paul Smolensky, and Colin Wilson (1995a). "When is Less More? Faithfulness and Minimal Links in *wh*-Chains." In Pilar *Is the Best Good Enough? Proceedings of the Workshop on Optimality in Syntax*. MIT, Cambridge, MA.

Legendre, Géraldine, Colin Wilson, Paul Smolensky, Kristin Homer, and William Raymond (1995b). "Optimality and *Wh*-Extraction." In Jill Beckman, Laura Walsh Dickey, and Suzanne Urbanczyk, eds., *Papers in Optimality Theory*, Occasional Papers in Linguistics 18, 607–636. University of Massachusetts, Amherst, MA.

Neville, Helen, Janet L. Nicol, Andrew Barss, Kenneth I. Forster, and Merrill F. Garrett (1991). "Syntactically Based Sentence Processing Classes: Evidence from Event-Related Brain Potentials." *Journal of Cognitive Neuroscience* 3:151–165.

Prince, Allan and Paul Smolensky (1993). *Optimality Theory: Constraint Interaction in Generative Grammar*. Technical Report 2, Center for Cognitive Science, Rutgers University, Brunswick, NJ.

Schütze, Carson T. (1996). *The Empirical Base of Linguistics. Grammaticality Judgments and Linguistic Methodology*. Chicago: University of Chicago Press.

Centre for Cognitive Science
University of Edinburgh
2 Buccleuch Place, Edinburgh EH8 9LW, UK

keller@cogsci.ed.ac.uk