Does Morphological Underspecification Exist?
Grammatical and Neurophysiological Evidence

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1. Introduction

Claims

Two claims:

- Evidence from grammatical theory suggests that underspecification may not exist: It is not needed for an account of systematic instances of syncretism in morphology if an optimality-theoretic approach is adopted.
  (Müller (2011; 2013))
- Evidence from neurophysiological studies suggests that underspecification exists after all: An EEG study reveals LAN differences between two kinds of ungrammatical morphological exponents (Compatibility vs. Specificity violations).
  (Opitz, Regel, Müller & Friederici (2013))

Data:

- The two studies address identical data: the paradigm of *pronominal/strong adjective inflection* in German.

Syncretism and Underspecification: Standard Approach

(1) *Prononominal inflection in German*

dies 'this'	MASC.SG	NEUTER.SG	FEMININE.SG	PLURAL
NOMINATIVE	er	es	e	e
ACCUSATIVE	en	es	e	e
DATIVE	em	em	er	en
GENITIVE	es	es	er	er

Assumption:
There are not 16 (24) different morphological exponents; many of the instances of syncretism are systematic, and show that the paradigm consists of a few markers that are underspecified with respect to decomposed, abstract morphological features.
(Bierwisch (1967), Blevins (1995), Sauerland (1996), Wunderlich (1997a), Wiese (1999), Müller (2003), Gallmann (2004), Sternefeld (2004), Trommer (2005); Jakobson (1962a;b) for the general idea).

Decomposition of Gender and Case

(2) *Decomposition of gender features in German* (Bierwisch (1967)):

a. masculine = [+masc,–fem]
b. feminine = [–masc,+fem]
c. neuter = [–masc,–fem]
d. [ ] = [+masc,+fem]

(3) *Decomposition of case features in German* (Bierwisch (1967)):

a. nominative = [–obj,–obl]
b. accusative = [+obj,–obl]
c. dative = [+obj,+obl]
d. genitive = [–obj,+obl]

Morphological Realization: Specificity and Compatibility

(4) *Inventory of exponents for pronominal inflection* (based on Blevins (1995))

a. /n/ ↔ [+pl,+obj,+obl] (dat.pl.)
b. /m/ ↔ [–fem,+obj,+obl] (dat.masc.sg./neut.sg.)
c. /s/ ↔ [–fem,+obl] (gen.masc.sg./neut.sg.)
d. /r/ ↔ [+obl] (dat./gen.fem.sg., gen.pl.)
e. /n/ ↔ [+masc,–fem,+obj,–obl] (acc.masc.sg.)
f. /r/ ↔ [+masc,–fem] (nom.masc.sg.)
g. /s/ ↔ [–fem] (nom./acc.neut.sg.)
h. /e/ ↔ [ ] (nom./acc.fem.sg./pl.)

Morphological Realization

(5) *Morphological Realization* ('Panini's Principle', 'Subset Principle', 'Elsewhere Principle', 'Proper Inclusion Principle', 'Blocking Principle'):
A morphological exponent M is chosen for a syntactic context (or paradigm cell) S if (a) and (b) hold.

a. M is compatible with S.
b. M is the most specific exponent among those that satisfy (5-a).

(6) *Compatibility*:
A morphological exponent M is compatible with a syntactic context (or paradigm cell) S if M realizes a *subset* of the morpho-syntactic feature/value pairs of S.

(7) *Specificity*:
A morphological exponent M_1 is more specific than a morphological exponent M_2 if M_1 realizes *more* features than M_2.

Morphological Realization cont'd

Note:
This kind of approach to syncretism is available in virtually all current morphological theories: Distributed Morphology (Noyer 1992; Halle & Marantz 1993; Harley & Noyer 2003), Minimalist Morphology (Wunderlich 1996; 1997b; 2004), A-morphous Morphology (Anderson 1992; Aronoff 1994), Paradigm Function Morphology (Stump 2001), Network Morphology (Corbett & Fraser 1993, Brown & Hippisley (2012)), and various accounts in Optimality Theory

(Grimshaw 2001, Trommer 2001; 2006)

(8) *Different compatible markers for accusative masculine singular contexts*

			syntactic context
			[+masc, –fem, −pl, +object, −oblique]
exponent	/n/	↔	[+masc, –fem, +object, −oblique]
	/r/	↔	[+masc, –fem,]
	/s/	↔	[–fem,]
	/e/	↔	[ ]

2. Against Morphological Underspecification

2.1 An Optimality-Theoretic Approach to Syncretism

Optimality-Theoretic Approaches to Morphology
Syncretism in Optimality Theory:

- Syncretism by underspecification: Grimshaw (2001), Wunderlich (2001; 2004), Trommer (2001; 2003; 2006), Ortmann (2002), Don & Blom (2006)
- Syncretism by optimality-theoretic versions of rules of referral: Xu & Aronoff (2008), Xu (2011)

Potential problems with underspecifiction from this perspective:

- Morphological underspeficiation implies systematic morphology/syntax mismatches: Why isn't underspecified information accessible by syntactic rules (like agreement, case assignment)?
- Underspecification is arguably a dubious concept from an optimality-theoretic point of view; it is a tool that belongs in a different model of grammar (Itô et al. (1995), Smolensky (2006))

Towards a New Approach Without Underspecification
Basic assumptions:

1. There is *no underspecification* of exponents.
2. Not all members of a paradigm (exponents) are present in the input; only *leadings forms* are (see Wurzel (1984), Blevins (2004), Finkel & Stump (2007; 2009), Albright (2008), and Baerman (2009) for related concepts).
3. A mismatch of paradigm cells and leadings forms gives rise to syncretism: Initial gaps are filled by using "wrong", i.e., *unfaithful exponents* (Weisser (2007)).
4. Mismatches between the exponent's specification and the target specification are minimized; this is accomplished by a set of *ranked faithfulness constraints* for the features involved (as in Grimshaw (2001), Trommer (2001; 2006), Wunderlich (2004)).

5. *Feature decomposition* yielding natural classes is needed as before; but a slightly different system of decomposed gender/number features is adopted for pronominal inflection in German (based on Wiese (1999)).

Feature Decomposition and Leading Forms

(9) *Decomposition of gender/number features in German* (Wiese (1999)):

a. masculine = [+masc,–fem]
b. feminine = [–masc,+fem]
c. neuter = [+masc,+fem]
d. plural = [–masc,–fem]

(10) *Nine leading forms*:

/r/$_1$ ↔ [+masc,–fem,–obj,–obl]
/n/$_2$ ↔ [+masc,–fem,+obj,–obl]
/m/$_3$ ↔ [+masc,–fem,+obj,+obl]
/s/$_4$ ↔ [+masc,–fem,–obj,+obl]
/s/$_5$ ↔ [+masc,+fem,+obj,–obl]
/e/$_6$ ↔ [–masc,+fem,–obj,–obl]
/n/$_7$ ↔ [–masc,–fem,+obj,+obl]
/r/$_8$ ↔ [–masc,+fem,–obj,+obl]
/r/$_9$ ↔ [–masc,–fem,–obj,+obl]

Violable Constraints

(11) MATCH:
The morpho-syntactic features of stem and exponent are identical in the output.

(12) *Faithfulness constraints for features on exponents*

a. IDENTMASC:
[±masc] of the input must not be changed in the output on an exponent.
b. IDENTOBL:
[±obl] of the input must not be changed in the output on an exponent.
c. IDENTFEM:
[±fem] of the input must not be changed in the output on an exponent.
d. IDENTOBJ:
[±obj] of the input must not be changed in the output on an exponent.

(13) *Ranking*:
IDENTMASC ≫ IDENTOBL ≫ IDENTFEM ≫ IDENTOBJ

The Basic Paradigm with Initial Gaps

(14) *Incomplete paradigm with leading forms only*

dies 'this'	MASC.SG	NEUTER.SG	FEMININE.SG	PLURAL
[–obj,–obl]	/r/$_1$		/e/$_6$	
[+obj,–obl]	/n/$_2$	/s/$_5$		
[+obj,+obl]	/m/$_3$			/n/$_7$
[–obj,+obl]	/s/$_4$		/r/$_8$	/r/$_9$

Sample Competitions 1

Tableau T_1: Nom.Neut.Sg. contexts

Input: dies ↔ [+masc,+fem,–obj,–obl], EXP	MATCH	IDENT MASC	IDENT OBL	IDENT FEM	IDENT OBJ
O_1: dies-r$_1$ ↔ [+masc,*–fem*,–obj,–obl]				*!	
O_2: dies-n$_2$ ↔ [+masc,*–fem*,*+obj*,–obl]				*!	*
O_3: dies-m$_3$ ↔ [+masc,*–fem*,*+obj*,*+obl*]			*!	*	*
O_4: dies-s$_4$ ↔ [+masc,*–fem*,–obj,*+obl*]			*!	*	
☞ O_5: dies-s$_5$ ↔ [+masc,+fem,*+obj*,–obl]					*
O_6: dies-e$_6$ ↔ [*–masc*,+fem,–obj,–obl]		*!			
O_7: dies-n$_7$ ↔ [*–masc*,*–fem*,*+obj*,*+obl*]		*!	*	*	*
O_8: dies-r$_8$ ↔ [*–masc*,+fem,–obj,*+obl*]		*!	*		
O_9: dies-r$_9$ ↔ [*–masc*,*–fem*,–obj,*+obl*]		*!	*	*	
O_{10}: dies-r$_1$ ↔ [+masc,–fem,–obj,–obl]	*!				

Note: EXP is an abstract case exponent that stands for the set of possible (fully specified) exponents of the inventory (see RED in McCarthy & Prince (1994)).

Sample Competitions 2

Tableau T_2: Acc.Pl. contexts

Input: dies ↔ [–masc,–fem,+obj,–obl], EXP	MATCH	IDENT MASC	IDENT OBL	IDENT FEM	IDENT OBJ
O_1: dies-r$_1$ ↔ [*+masc*,–fem,*–obj*,–obl]		*!			*
O_2: dies-n$_2$ ↔ [*+masc*,–fem,+obj,–obl]		*!			
O_3: dies-m$_3$ ↔ [*+masc*,–fem,+obj,*+obl*]		*!	*		
O_4: dies-s$_4$ ↔ [*+masc*,–fem,*–obj*,*+obl*]		*!	*		*
O_5: dies-s$_5$ ↔ [*+masc*,*+fem*,+obj,–obl]		*!		*	
☞ O_6: dies-e$_6$ ↔ [–masc,*+fem*,*–obj*,–obl]				*	*
O_7: dies-n$_7$ ↔ [–masc,–fem,+obj,*+obl*]			*!		
O_8: dies-r$_8$ ↔ [–masc,*+fem*,*–obj*,*+obl*]			*!	*	*
O_9: dies-r$_9$ ↔ [–masc,–fem,*–obj*,*+obl*]			*!		*
O_{10}: dies-r$_1$ ↔ [+masc,–fem,–obj,+obl]	*!				

Sample Competitions 3

Tableau T_3: Dat.Fem.Sg. contexts

Input: dies ↔ [–masc,+fem,+obj,+obl], EXP	MATCH	IDENT MASC	IDENT OBL	IDENT FEM	IDENT OBJ
O_1: dies-r$_1$ ↔ [*+masc*,*–fem*,*–obj*,*–obl*]		*!	*	*	*
O_2: dies-n$_2$ ↔ [*+masc*,*–fem*,+obj,*–obl*]		*!	*	*	
O_3: dies-m$_3$ ↔ [*+masc*,*–fem*,+obj,+obl]		*!		*	
O_4: dies-s$_4$ ↔ [*+masc*,*–fem*,*–obj*,+obl]		*!		*	*
O_5: dies-s$_5$ ↔ [*+masc*,+fem,+obj,*–obl*]		*!	*		
O_6: dies-e$_6$ ↔ [–masc,+fem,*–obj*,*–obl*]			*!		*
O_7: dies-n$_7$ ↔ [–masc,*–fem*,+obj,+obl]				*!	
☞ O_8: dies-r$_8$ ↔ [–masc,+fem,*–obj*,+obl]					*
O_9: dies-r$_9$ ↔ [–masc,*–fem*,*–obj*,+obl]				*!	*
O_{10}: dies-r$_1$ ↔ [+masc,–fem,–obj,+obl]	*!				

The Complete Paradigm Without Gaps

(15) *Complete paradigm with spreading of leading forms*

dies 'this'	MASC.SG [+masc,–fem]	NEUTER.SG [+masc,+fem]	FEMININE.SG [–masc,+fem]	PLURAL [–masc,–fem]
[–obj,–obl]	/r/$_1$	↑	/e/$_6$	→
[+obj,–obl]	/n/$_2$	/s/$_5$	↓	↘
[+obj,+obl]	/m/$_3$	→	↑	/n/$_7$
[–obj,+obl]	/s/$_4$	→	/r/$_8$	/r/$_9$

An Empirical Difference: 8 vs. 9 basic forms

(16) *Incomplete paradigm of German determiner inflection: a wrong prediction*

dies 'this'	FEMININE.SG [–masc,+fem]	PLURAL [–masc,–fem]
[+obj,+obl]		/n/$_7$
[–obj,+obl]	/r/$_8$	

Tableau T_4: A wrong prediction for Gen.Pl. contexts if /r/$_9$ is not present

Input: dies ↔ [–masc,–fem,–obj,+obl], EXP	IDENT MASC	IDENT OBL	IDENT FEM	IDENT OBJ
☛ O_7: dies-n$_7$ ↔ [–masc,–fem,*+obj*,+obl]				*
O_8: dies-r$_8$ ↔ [–masc,*+fem*,–obj,+obl]			*!	

Tableau T_5: A wrong prediction for Dat.Fem.Sg. contexts under reranking

Input: dies ↔ [–masc,+fem,+obj,+obl], EXP	IDENT MASC	IDENT OBL	IDENT OBJ	IDENT FEM
☛ O_7: dies-n$_7$ ↔ [–masc,*–fem*,+obj,+obl]				*
O_8: dies-r$_8$ ↔ [–masc,+fem,*–obj*,+obl]			*!	

Contextual Faithfulness – A Way Out?
Contextual faithfulness:
Faithfulness constraints can be restricted to certain environments (Beckmann (1998), Wunderlich (2004), Woolford (2007)).

Tableau T_6: Correct prediction for Gen.Pl. contexts without /r/$_9$: contextual faithfulness

Input: dies ↔ [–masc,–fem,–obj,+obl], Exp	Ident Masc	Ident Obl	Ident Obj([–fem])	Ident Fem	Ident Obj
O_7: dies-n$_7$ ↔ [–masc,–fem,*+obj*,+obl]			*!		*
☞ O_8: dies-r$_8$ ↔ [–masc,*+fem*,–obj,+obl]				*	

9 Forms Might Be Better Anyway
Assumption (Eisenberg (2000), Zifonun (2001)):
Only those instances of homonymy should be viewed as instances of systematic syncretism by underspecification where the identity of inflectional exponents is maintained with *all* material in the agreement-sensitive edge domain of an NP (except for the elsewhere marker).

(17)
a. [+obj,+obl,+pl] ↔ /n/$_a$ (dat.pl.)
diesen alten Frauen 'these old women'
b. [–fem,+obj,+obl] ↔ /m/$_b$ (dat.masc.sg./neut.sg.)
diesem alten Mann(e), diesem alten Buch(e) 'this old man', 'this old book'
c. [–fem,+obl] ↔ /s/$_c$ (gen.masc.sg./neut.sg.)
dieses alten Mannes, dieses alten Buches 'this old man', 'this old book'
d. [+obl] ↔ /r/$_{d1}$ (dat./gen.fem.sg.)
dieser alten Frau, *dieser alten Frau* 'this old woman'
e. [+obl] ↔ /r/$_{d2}$ (gen.pl.)
dieser alten Frauen 'these old women'
f. [+masc,-fem,+obj,–obl] ↔ /n/$_e$ (acc.masc.sg.)
diesen alten Mann 'this old man'
g. [+masc,–fem] ↔ /r/$_f$ (nom.masc.sg.)
dieser alte Mann 'this old man'
h. [–fem] ↔ /s/$_g$ (nom./acc.neut.sg.)
dieses alte Buch, dieses alte Buch 'this old book'
i. [ ] ↔ /e/$_h$ (nom./acc.fem.sg./pl.)
diese alte Frau, diese alten Frauen 'this old woman', 'these old women'

2.2 An Extension to Deponency

From Syncretism to Deponency
Deponency:
(Generalized) deponency is the legitimate use of wrong forms in grammar.
(Baerman (2007): a mismatch between form and function.)

- Unlike the standard, underspecification-based approach, the optimality-theoretic approach just sketched can also be straightforwardly extended to instances of *deponency* (see Spencer (2007) and Corbett (2007) on similarities between syncretism and deponency).
- In both cases, minimally unfaithful forms become optimal because of the need to fill what would otherwise be a paradigmatic gap. The main difference is that in the present optimality-theoretic approach to syncretism, the need for an unfaithful winner arises as the consequence of an initial paradigmatic gap, whereas it arises as a consequence of specific *feature co-occurrence restrictions* (FCRs) in the approach to (generalized) deponency that blocks the use of the expected form with certain lexical items.

General Features of the OT Approach to Deponency

1. As with the optimality-theoretic approach to syncretism sketched above, an *unfaithful (leading) exponent* emerges as optimal.
2. However, the trigger is not an initial paradigmatic gap (absence of a leading form) but a *lexical specification* on the stem (a feature co-occurrence restriction (FCR), see Gazdar et al. (1985)) that expresses an incompatibility with the regular exponent's morpho-syntactic features.
3. The *fewer features* the FCR excludes, the *more cells* will be affected by the deponency.
4. The *more stems* the FCR applies to, the *more general* the deponency pattern will be.
5. As with many other approaches to deponency (e.g., Embick (2000), Kiparsky (2005), Bobaljik (2007), Hippisley (2007), Schulz (2010)), *defectivity* does not automatically follow as a general property of deponency. It is logically independent and where it holds, it must be derived by some additional means.
6. The analysis predicts that unfaithful exponents chosen in cases of deponency are *not arbitrary* (as is the case, e.g., with the Network Morphology analyses developed in Hippisley (2007) for Latin deponent verbs and Archi deponent nouns, and in Brown (2006) for spurious antipassive in Chukchi, verbal case on nouns in Kayardild, and polarity effects with telic and atelic verb stems in Tülatulabal; or with the Paradigm Function Morphology analyses in Sadler & Spencer (2001), Stump (2006)). Rather, the unfaithful exponents must differ *minimally* from the regularly expected exponent.

Noun Inflection in Archi
Refs.: Kibrik (1991; 2003), Mel'čuk (1999), Corbett (2007), Hippisley (2007), Keine & Hein (2010)

(18) Partial paradigm of some regular nouns in Archi

	aInš ('apple')		*qIin* ('bridge')		*áʕrum* ('sickle')	
	SG	PL	SG	PL	SG	PL
ABS	aInš-Ø	aInš-um	qIin-Ø	qionn-or	áʕrum-Ø	áʕrum-mul
ERG	aInš-li	aInš-um-čaj	qIin-i	qionn-or-čaj	áʕrum-li	áʕrum-mul-čaj
GEN	aInš-li-n	aInš-um-če-n	qIin-i-n	qionn-or-če-n	áʕrum-li-n	áʕrum-mul-če-n
DAT	aInš-li-s	aInš-um-če-s	qIin-i-s	qionn-or-če-s	áʕrum-li-s	áʕrum-mul-če-s
COMIT	aInš-li-ɬ:u	aInš-um-če-ɬ:u	qIin-i-ɬ:u	qionn-or-če-ɬ:u	áʕrum-li-ɬ:u	áʕrum-mul-če-ɬ:u
...						

Note:
The system involves (i) *parasitic (Priscianic) formation*, where oblique case forms are derived from the ERG form; and (ii) *extended exponence*: /li/ is an ergative singular exponent; /čaj/ is an ergative plural exponent; and /um/, /or/, /mul/ are plural exponents sensitive to noun class.

Deponent Nouns in Archi

(19) Partial paradigm of deponent nouns with plural markers in singular contexts

	haʕtəra ('river')		*c′aj* ('female goat')	
	SG	PL	SG	PL
ABS	haʕtəra-Ø	haʕtər-mul	c′aj-Ø	c′ohor-Ø
ERG	haʕtər-*čaj*	haʕtər-mul-čaj	c′ej-*t̄aj*	c′ohor-čaj
...				

Note: Choice of *t̄aj* vs. *čaj* is determined by consonant-final vs. vowel-final roots.

(20) Partial paradigm of the deponent (and suppletive) noun 'xʕon' with singular markers in plural contexts

	xʕon ('cow')	
	SG	PL
ABS	xʕon-Ø	buc:′i
ERG	xʕin-i	buc:′i-*li*
...		

Optimality-Theoretic Analysis of Deponent Nouns in Archi

(21) *Case and number features*:

a. *Case*		b. *Number*	
ABS:	[–obl]	SG:	[–pl]
ERG:	[+obl]	PL:	[+pl]
DAT:	[+obl,+obj]		
...			

(22) MATCH (undominated, possibly part of GEN):
The morpho-syntactic features of stem and exponent are identical in the output.

(23) LEX (undominated, possibly part of GEN):
A stem with FCR *[α] cannot be combined with an exponent bearing [α] in the input (where α is a – possibly singleton – set of morpho-syntactic features).

LEX refers to the input properties of an exponent, *not* to its output properties (which may have been changed, triggered by MATCH). See Trommer (2006) for this kind of reference to inputs in optimality-theoretic constraints. One way to implement this would be to assume that LEX applies to structure-building directly (in which case candidates violating it would not be part of the competition).

(24) *Faithfulness constraints for features on exponents*

a. IDENTOBL(IQUE):
[±obl] of the input must not be changed in the output on an exponent.

b. IDENTNUM(BER):
[±pl] of the input must not be changed in the output on an exponent.

Plural Markers in Singular Contexts

Tableau T_7: Erg.Sg., unfaithful winner

Input: haʕtər-$_{[+obl,-pl]}$ + EXP *[+obl,–pl]	LEX	MATCH	IDENT OBL	IDENT NUM
O_1: haʕtər$_{[+obl,-pl]}$-li { I: [+obl,–pl] / O: [+obl,–pl] }	*!			
O_2: haʕtər$_{[+obl,-pl]}$-čaj { I: [+obl,+pl] / O: [+obl,+pl] }		*!		
O_3: haʕtəra$_{[+obl,-pl]}$-Ø { I: [*–obl*,–pl] / O: [*+obl*,–pl] }			*!	
☞ O_4: haʕtər$_{[+obl,-pl]}$-čaj { I: [+obl,*+pl*] / O: [+obl,*–pl*] }				*

Singular Markers in Plural Contexts

Note:
No attempt is made here to account for stem selection/suppletion. As with multiple EXP optimization (which is also required), this issue is orthogonal to the deponency issue.

Deponent Verbs in Latin

Tableau T_8: Erg.Pl., unfaithful winner

Input: buc:ʼi$_{[+obl,+pl]}$ + EXP *[+obl,+pl]	LEX	MATCH	IDENT OBL	IDENT NUM
O_1: buc:ʼi$_{[+obl,+pl]}$-čaj { I: [+obl,+pl] / O: [+obl,+pl] }	*!			
O_2: buc:ʼi$_{[+obl,+pl]}$-li { I: [+obl,–pl] / O: [+obl,–pl] }		*!		
☞ O_3: buc:ʼi$_{[+obl,+pl]}$-li { I: [+obl,*–pl*] / O: [+obl,*+pl*] }				*
O_4: buc:ʼi$_{[+obl,+pl]}$-Ø { I: [*–obl*,*–pl*] / O: [*+obl*,*+pl*] }			*!	*

(25)

	regere ('rule')		hortārī ('urge')	
	ACT	PASS	ACT	PASS
PRES IND	regit	regitur	hortātur	—
PRES INF	regere	regī	hortārī	—
PRF IND	rēxit	rēctus est	hortātus est	—
PTCP PERF	—	rēctus	hortātus	—
SUPINE	rēctum	—	hortātum	—
PART PRES	regēns	—	hortāns	—

Sketch of an analysis:

- Deponent verb stems are equipped with the FCR *[–pass].
- The unfaithful output respecting LEX that has the best constraint profile is one that violates IDENTPASS.
- Semi-deponent verbs in Latin like *gaudēre* ('rejoice'), which have passive forms for active contexts only in the perfect, can be accounted for by assuming a FCR *[–pass,+perf] for the stems involved.
- Defectivity does not yet follow (also cf. Embick (2000), Kiparsky (2005), Bobaljik (2007), Hippisley (2007)).

Bridge

So far, so good. Underspecification is not needed to account for syncretism in a systematic way if a faithfulness-based optimality-theoretic approach is adopted, with roughly the same empirical coverage and number of assumptions. And the same approach can also be generalized so as to cover deponency, where an underspecification-based approach has nothing insightful to say.

Unfortunately, neurophysiological evidence argues for underspecification after all, on the basis of the very same empirical data, as shown by a study carried out in cooperation with Andreas Opitz, Stefanie Regel, and Angela D. Friederici.

3. In Support of Morphological Underspecification

A Neurophysiological Study: The Event-Related Potential Violation Paradigm
Opitz, Regel, Müller & Friederici (2013):

- If underspecification is real, *Compatibility* vs. *Specificity* should also be an inherent part of the language processing system. One should therefore be able to observe separable effects for the violation of each of the criteria.
- The *Event-Related Potential (ERP)* violation paradigm can be used to test this hypothesis in the domain of strong adjective inflection in German.
- *Prediction*: There should be differences in brain potentials between two incorrect conditions whenever they represented different types of violation (of Compatibility and Specificity).
- *Result*: The findings strongly support underspecification: An ERP-component related to morpho-syntactic integration (viz., *left anterior negativity; LAN*) was modulated by violations of Specificity versus Compatibility.
- Furthermore: The neurophysiological evidence helps to distinguish between two kinds of morphological underspecification that have been proposed: It argues for *maximal* rather than *minimal* underspecification.

3.1 Experiment

Setting the Stage
Premise:

- Since pronominal inflection involves only closed-class items which are presumably stored as full forms in the mental lexicon, the experimental design made the choice of the strong adjective paradigm mandatory.
- This is unproblematic since the two paradigms are identical except for genitive masculine/neuter singular contexts, where pronominal inflection has an exponent *-es* and strong adjective inflection has an exponent *-en*, with exactly the same role in the system.
- The study focuses on accusative exponents where there is no difference; one can thus look at underspecification-based analyses of pronominal inflection as analyses of strong adjective inflection by extension.

(26) *Material: PPs with accusative NPs of all three genders*

a. durch schlicht-e Struktur
by plain- FEM.SG.ACC structure. FEM

b. durch schlicht-en Geschmack
by plain- MASC.SG.ACC taste. MASC

c. durch schlicht-es Design
by plain- NEUT.SG.ACC design.neut

Maximal vs. Minimal Underspecfication
Two kinds of (extensionally equivalent) underspecification approaches:

- *Maximal underspecification*: minimal number of features on a morphological exponent; reduces complexity of the lexical component.
- *Minimal underspecification*: maximal number of features on a morphological exponent that still accounts for syncretism; might reduce complexity of the processing component; simple learning algorithms exist (Harley (2001), Pertsova (2007), based on *intersecting* the sets of the different (fully specified) environments; as soon as a minimally underspecified exponent can be postulated, the algorithm stops).

Prediction:

1. With maximal underspecification, ungrammatical exponents will, as a tendency, more often be blocked by Specificity.
2. With minimal underspecifiction, ungrammatical exponents will, as a tendency, more often be blocked by Compatibility.
3. Exponents that are blocked in the same way in one approach may therefore be blocked in different ways in the other approach.
4. We expect an identical ERP profile in the first case but not in the second case.

(27) *Inventory of exponents in Blevins (1995), with maximal underspecification* (= (4))

a. /n/ ↔ [+pl,+obj,+obl] (dat.pl.)
b. /m/ ↔ [–fem,+obj,+obl] (dat.masc.sg./neut.sg.)
c. /s/ ↔ [–fem,+obl] (gen.masc.sg./neut.sg.)
d. /r/ ↔ [+obl] (dat./gen.fem.sg., gen.pl.)
e. */n/* ↔ [+masc,–fem,+obj,–obl] (acc.masc.sg.)
f. /r/ ↔ [+masc,–fem] (nom.masc.sg.)
g. */s/* ↔ [–fem] (nom./acc.neut.sg.)
h. */e/* ↔ [ ] (nom./acc.fem.sg./pl.)

(28) *Inventory of exponents in Blevins (1995), with minimal underspecification*

a. /n/ ↔ [+pl,+obj,+obl] (dat.pl.)
b. /m/ ↔ [–fem,+obj,+obl,*–pl*] (dat.masc.sg./neut.sg.)
c. /s/ ↔ [–fem,+obl,*–obj*,*–pl*] (gen.masc.sg./neut.sg.)
d. /r/ ↔ [+obl] (dat./gen.fem.sg., gen.pl.)
e. */n/* ↔ [+masc,–fem,+obj,–obl,*–pl*] (acc.masc.sg.)
f. /r/ ↔ [+masc,–fem,*–obl*,*–obj*,*–pl*] (nom.masc.sg.)
g. */s/* ↔ [*–masc*,–fem,*–obl*,*–pl*] (nom./acc.neut.sg.)
h. */e/* ↔ [*–obl*]

Predictions under Maximal Underspecification

(29) *Two types of illicit agreement, with maximal underspecification (as in (27))*:

a. for feminine phrases:
identical kind of violation (Compatibility)
context features: [–masc, +fem, –obl, +obj]
correct marker: -e [ ]
incompatible (incorr.1): -(e)n [**+masc, –fem**, –obl, +obj]
incompatible (incorr.2): -(e)s [**–fem**]

b. for masculine phrases:
identical kind of violation (Specificity)
context features: [+masc, –fem, –obl, +obj]
correct: -(e)n [+masc, –fem, –obl, +obj]
compatible (incorr.1): -(e)s [–fem]
compatible (incorr.2): -e [ ]

c. for neuter phrases:
different kind of violation (Compatibility vs. Specificity)
context features: [–masc, –fem, –obl, +obj]
correct: -(e)s [–fem]
incompatible (incorr.1): -(e)n [**+masc**, –fem, –obl, +obj]
compatible (incorr.2): -e [ ]

Predictions under Minimal Underspecification

(30) *Two types of illicit agreement, with minimal underspecification (as in (28))*:

a. for feminine phrases:
identical kind of violation (Compatibility)

context features: [–masc, +fem, –obl, +obj, –pl]
correct marker: -e [–obl]
incompatible (incorr.1): -(e)n [**+masc, –fem**, –obl, +obj, –pl]
incompatible (incorr.2): -(e)s [–masc, **–fem**, –obl, –pl]

b. for masculine phrases:
different kind of violation (Compatibility vs. Specificity)
context features: [+masc, –fem, –obl, +obj, –pl]
correct: -(e)n [+masc, –fem, –obl, +obj, –pl]
incompatible (incorr.1): -(e)s [**–masc**, –fem, –obl, –pl]
compatible (incorr.2): -e [–obl]

c. for neuter phrases:
different kind of violation (Compatibility vs. Specificity)
context features: [–masc, –fem, –obl, +obj, –pl]
correct: -(e)s [–masc, –fem, –obl, –pl]
incompatible (incorr.1): -(e)n [**+masc**, –fem, –obl, +obj, –pl]
compatible (incorr.2): -e [–obl]

Predictions:
(A) No, (B) Maximal, (C) Minimal Underspecification

(31) *Predictions: assumed processing differences for different incorrect markers*

		model		
		without underspec.	with underspecification	
noun gender		categorical	maximal	minimal
feminine	(*corr. e*)	$s = n$	$s^2 = n^2$	$s^2 = n^2$
neuter	(*corr. s*)	$e = n$	$e^1 < n^2$	$e^1 < n^2$
masculine	(*corr. n*)	$e = s$	$e^1 = s^1$	$e^1 < s^2$

Notational conventions:
[1] signals a violation of Specificity; [2] signals a violation of Compatibility; α=β indicates the same type of violation/the same processing; and α<β indicates a different type of violation/different processing

Method
Items:

- 180 nouns (60 masculine, 60 feminine, 60 neuter)
- matched for length, frequency, plausibility, familiarity, derived/non-derived
- each item in 3 different correctness conditions (correct, incorrect1, incorrect2)
- = 540 experimental items
- 3 randomized lists, 240 items each list:
  - all 180 nouns (60 correct, 60 incorr1, 60 incorr2)
  - 60 correct fillers

(32) *Experimental design/conditions*

	masculine NP 'without new discount'	neuter NP 'without new genre'	feminine NP 'without new probe'
correct	ohne neuen Rabatt	ohne neues Genre	ohne neue Sonde
incorrect 1	ohne neues Rabatt	ohne neuen Genre	ohne neuen Sonde
incorrect 2	ohne neue Rabatt	ohne neue Genre	ohne neues Sonde

Participants

- 42 German native speakers
- 21 male, 21 female
- all right-handed

Procedure

- visual word-by-word presentation:
  400ms each word, 300ms ISI
- recording of EEG (51 electrodes according to the international 10-20 system)
- compared ERP for the processing of the noun (establishing/validation of agreement)
- grammaticality judgement after each trial (producing behavioural data)

Technical details

- grand averages were obtained for 1200ms epochs beginning 200 ms prior to the presentation of the critical stimuli (i.e., the nouns)
- time windows for analysis: 300-550ms; 600-900ms
- 4 Regions Of Interest (ROI), each containing 6 electrodes:
  left anterior: F5, F3, FC5, FC3, C5, C3
  right anterior: F4, F6, FC4, FC6, C4, C6
  left posterior: CP5, CP3, P5, P3, PO7, PO3
  right posterior: CP4, CP6, P4, P6, PO4, PO8
  (midline)

Presentation

(33)

-*-	[ ]	prep	[ ]	adj	[ ]	noun	[ ]
500ms	300ms	400ms	300ms	400ms	300ms	400ms	800ms

Results: Electrophysiological Data; Left-Anterior Negativity

	Anterior Sites				Posterior Sites		Midline Sites	
	left anterior		right anterior					
	df	F	df	F	df	F	df	F
Marker	2,82	14.23***	2,82	17.71***	2,82	11.26**	2,82	14.25***
Gender x Marker	4,164	6.13**	4,164	2.49(*)	4,164	2.37(*)	4,164	2.39(*)
Feminine								
Marker	2,82	8.44***	2,82	6.19**	2.82	5.01**	2,82	3.02(*)
cor vs incor1	1,41	13.9***	1,41	8.64**	1,41	n.s.	1,41	n.s.
cor vs incor2	1,41	6.40*	1,41	8.74**	1,41	8.41**	1,41	n.s
incor1 vs incor2	1,41	n.s.	1,41	n.s.	1,41	n.s.	1,41	n.s.
Neuter								
Marker	2,82	17.49***	2.82	11.53***	2,82	7.87***	2,82	12.93***
cor vs incor1	1,41	36.59***	1,41	25.54***	1,41	10.71**	1,41	19.41***
cor vs incor2	1,41	12.78**	1,41	9.47**	1,41	10.12**	1,41	16.16**
incor1 vs incor2	1,41	4.17*	1.41	n.s.	1.41	n.s.	1,41	n.s.
Masculine								
Marker	2,82	n.s.	2,82	n.s.	2,82	n.s.	2,82	n.s.

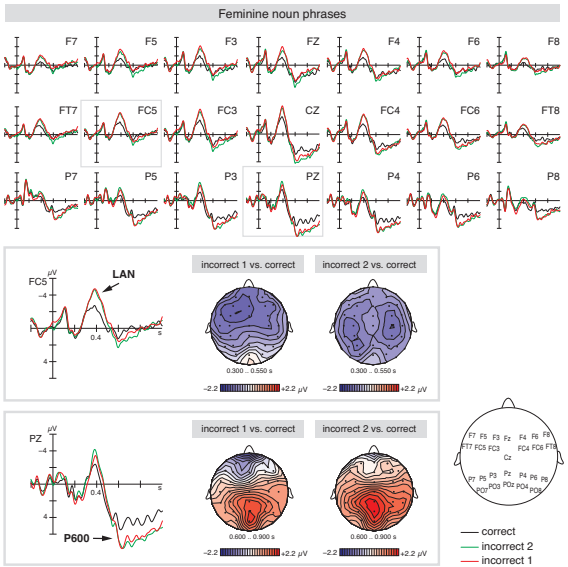
Table 9: *Effects of the step-down ANOVAs for anterior and posterior sites and the ANOVAs for the midline sites of the 300–550 ms latency window*

Abbreviations used in this table: cor = correct; incor1 = incorrect1; incor2 = incorrect2; (*) = p<.10; * = p<.05; ** = p<.01; *** = p<.001; n.s. = not significant.

Results: Electrophysiological Data; P600

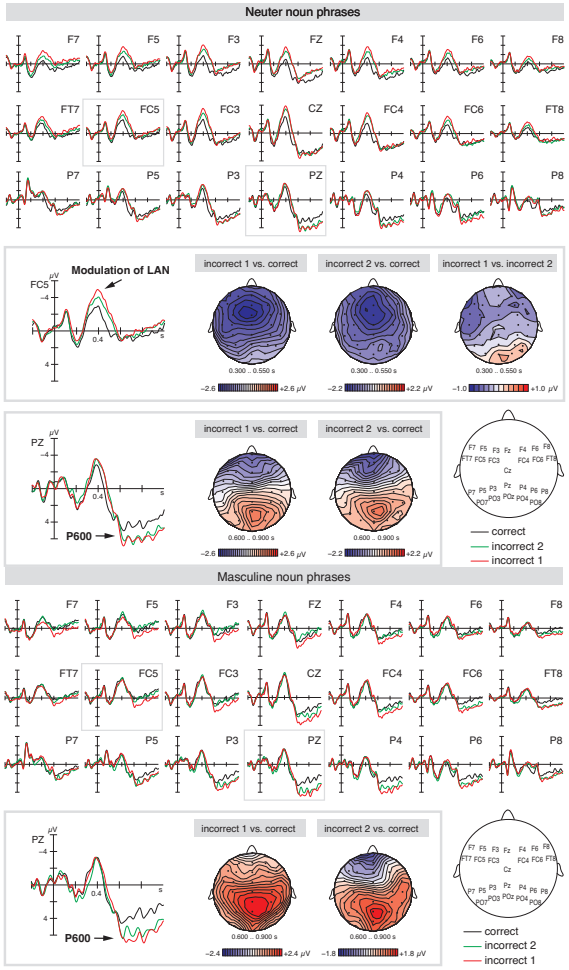
	Anterior Sites		Posterior Sites		Midline Sites	
	df	F	df	F	df	F
Marker	2,82	n.s.	2,82	10.07***	2,82	6.146**
Gender	2,82	n.s.	2,82	3.45*	2,82	2.62(*)
Gender x Marker	4,164	3.72**	4,164	n.s.	4,164	2.44(*)
Feminine						
Marker	2,82	2.71(*)			2,82	5.42**
cor vs incor1	1,41	n.s.			1,41	n.s.
cor vs incor2	1,41	n.s.			1,41	9.40**
incor1 vs incor2	1,41	n.s.			1,41	n.s.
Neuter						
Marker	2,82	n.s.			2,82	n.s.
Masculine						
Marker	2,82	4.88**			2,82	5.21**
cor vs incor1	1,41	9.25**			1,41	12.73***
cor vs incor2	1,41	n.s.			1,41	n.s.
incor1 vs incor2	1,41	n.s.			1,41	n.s.

Table 10: *Effects of the step-down ANOVAs for anterior and posterior sites and the ANOVAs for the midline sites of the 600-900 ms latency window*



3.2 Discussion

Two Main Results



(34) Background

a. Left-Anterior Negativity (LAN): indicative of morpho-syntactic violations (but see below for a qualification)

b. P600: indicative of reanalysis and repair

- LAN:
  1. In *feminine* contexts, where /e/ is correct, the two incorrect exponents /n/ and /s/ produce the same effect.
  2. In *neuter* contexts, where /s/ is correct, the two incorrect exponents /s/ and /e/ produce different effects. (This is the main result of the study.)
  3. In *masculine* contexts, where /n/ is correct, the two incorrect exponents /s/ and /e/ produce the same effect. Surprisingly, the *correct* marker /n/ also produces this effect. (This is also an interesting result.)
- P600: This effect showed up in the same way with all incorrect exponents.
- The LAN effects with *incorrect* forms in *neuter* contexts gives rise to a direct argument for underspecification.
- The LAN effect with *correct* forms in *masculine* contexts gives rise to a more indirect argument for underspecification.

I: Comparing Incorrect Conditions for Each Gender

(35) *Predictions and results*

	Predictions			Results	
	without underspec.	with underspecification			
noun gender	categorical	maximal	minimal	LAN	P600
feminine	s = n	$s^2 = n^2$	$s^2 = n^2$	s = n	s = n
neuter	e = n	$e^1 < n^2$	$e^1 < n^2$	$e < n^*$	e = n
masculine	e = s	$e^1 = s^1$	$e^1 < s^2$	e = s	e = s

Conclusions:

- The different LAN effect with /e/ and /n/ in neuter contexts strongly argues for the reality of a difference between *Compatibility* and *Specificity*, i.e., for underspecification.
- The absence of a LAN effect with /e/ and /s/ in masculine contexts strongly argues for *maximal* rather than *minimal* underspecification.

II: An Effect of Feature Matching

Question:
Why is there a LAN effect for correct masculine forms that is indistinguishable from the LAN effect for the two incorrect forms?
Answer: This is an effect of feature matching.

(36) *Proposal*:

a. $[_{PP}$ P $[_{NP}$ A N $]]$ is parsed incrementally.
b. P is read in; [+obj,–obl] (= acc) is available at this point.
c. A is encountered. Gender information on A becomes available (if there is any): [+masc,–fem] with /n/, [–fem] with /s/, and no gender feature with /e/; A's case specification (if there is any) is now accessible. P-A agreement is carried out, comparing the case features of P and A. If there are no conflicts, potentially missing case features of the preposition are copied onto the adjective, yielding full case specifications on A.
d. N enters the structure. It has specified gender information and fully specified number information, but no case information whatsoever yet. A-N agreement is carried out; the morpho-syntactic features of N are matched with the morpho-syntactic features of A.

Agreement Evaluation

(37) *Sizes of feature sets in well-formed NPs before A-N agreement*

a. durch (by) [−obl, +obj] — schlichten (plain.MASC) [+masc, −fem; −obl, +obj] — Geschmack (taste.MASC) [+masc, −fem] ← *most features compared:* 4/2
b. durch (by) [−obl, +obj] — schlichtes (plain.NEUT) [−fem; −obl, +obj] — Design (design.NEUT) [−masc, −fem] ← *fewer features compared:* 3/2
c. durch (by) [−obl, +obj] — schlichte (plain.FEM) [−obl, +obj] — Struktur (structure.FEM) [−masc, +fem] ← *fewest features compared:* 2/2

Conclusions:

- The LAN effect with correct masculine forms is due to the fact that the most features need to be compared in incremental agreement, outweighing the LAN effect with the incorrect forms here.
- This provides a second, albeit indirect, argument for morphological underspecification: Underspecification actually facilitates processing (as it facilitates lexical storage).

4. Conclusion

Conclusion

Take-home message:

- Neurophysiological evidence argues for morphological underspecification.
- Unless one can accomodate the evidence in a theoretical approach that does without underspecification in inflectional morphology, such an approach is thus called into question, whatever its conceptual merits (internal to grammatical theory).
- Accomodating the evidence on the basis of the optimality-theoretic approach developed above will not work, given that all non-optimal candiates are ungrammatical in the same way.
  (Things might perhaps be different if a gradient, non-categorical approach to optimality theory is adopted – but even then, there can be no categorical difference between incorrect forms, as would seem to be required by the neurophysiological evidence. Furthermore, in (15), /n/ would indeed have a better constraint profile than /e/ in accusative neuter singular contexts where /s/ is correct: IdentFem is easier to violate than IdentMasc.)

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