Minimal feature deviance at word transition in incremental language processing

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German—a highly inflectional language—uses morphology to mark case, number and gender. Word transitions allow for insights into incremental mechanisms. For the built-up of (un)grammatical PPs (preposition - adjective - noun), Opitz et al. (2013) found graded LAN effects on the noun and attributed them to feature checking mechanism that distinguished between the violations of specificity and compatibility principles: The former describes the lack and the latter the opposition of the noun's features relative to the specification of a preceding adjective. Compared to the grammatical PP, lacking and opposing noun features entailed minor and major ungrammaticality cues and yielded attenuated and pronounced LANs. Subsequent research did not support the division of specificity and compatibility (Opitz & Pechmann 2014, 2016). Suggesting that these two principles may be too rigid to be guiding mechanisms in online comprehension, we propose a minimality-driven approach that subsumes specificity and compatibility: The **difference** between the feature sets of two elements should be as **minimal** as possible. Accordingly, morphosyntax-related processing effort should be low. This can be tested during the built-up of grammatical clause-medial DPs consisting of accidentally syncretic determiners (D) *der* and *den* ("the") followed by a weak adjective (A) and a noun (N) (see 1-4 in Tab. 1). Tab. 2 illustrates the syncretism between the two Ds as well as Bierwisch's (1967) corresponding feature specifications for all positions of 1-4. We predict that those transitions—be it from **∅ to D**[1], from the **D to A** and from **A to N**—should be easier to process for those contact points where minimally deviant feature sets are involved. Conversely, we predict more pronounced LAN effects for transitions with more deviant feature sets.

19 participants judged the grammaticality of items such as 1-4 (N=160) while ERPs were recorded and analyzed relative to D, A and N. Though we did not detect a LAN, we found broadly distributed negativities (NEG) (see Fig. 1; Tab. 3): For D, the ERPs reveal the following gradation: ***D: 1/2 < 3/4***. Following D1/2, A2 exerted more processing demands than A1. A3/4 following D3/4 produced the strongest effect: ***A: 1 < 2 < 3/4***. (see Fig. 2; Tab. 4). For N, only N4 differed significantly from the other Ns: ***N: 1 = 3 = 4 < 3*** (see Fig. 3; Tab. 5).

We attribute the D, A and N NEGs to different featural transitions. Following our argument from above, the notion of two minimally differing feature sets A and B can be formalized as $\boldsymbol{\#(\overline{A \cap B})}$ **→ "low"**. Tab. 6 lists the cardinalities for the three transitions ∅ to D, D to A and A to N: In D1/2, D is integrated as D1 and not as D2 since the former has a lower cardinality than the latter, hence a lower feature deviance. In 3-4, D is integrated as D3 for the same reason. Comparing D1/2 with D3/4 reveals a lower cardinality for the former. This is also reflected by the more pronounced NEG for the latter structures. Similarly, we would explain the NEG for the A position. However, the cardinality for A2 is higher than A3/4 in comparison to A1 but we found the opposite gradation. The supposed advantage for A3/4 may be negatively compensated due to the additional features that have to be compared or the resolution of the disjunction. At the N position, all nouns cluster together expect for N2. This may be due to the conflicting gender feature that categorially opposes the earlier D-A-integration. In this way, the detected ERP pattern at the N position also partially contradicts the cardinalities in Tab. 6.

These findings support a basic processing strategy, namely the checking for minimal feature deviance, when incrementally building up a structure. The more the upcoming input featurally deviates from the previous analysis, the harder the integration becomes. Although we cannot fully rule out an incrementally operating mechanism that relies on compatibility checking, the current proposal is simpler. While incompatibility may be a plausible threshold to evoke pronounced ERP responses, a gradually increasing feature deviance cannot yet be ruled out. In this way, our data support the assumption of a mental lexicon comprised of morphosyntactically (under)specified entries (e.g. Bierwisch 1967). It also suggests that a minimality driven principle contributes to morphosyntactic processing.

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[1] Note that D is presumably the first position to introduce features. Thus, prior to D there are none, hence "∅".

			D	A	N		
1)	Gestern	hat	der	nette$_{NOM, ACC}$	Typ$_{NOM}$	den Jungen$_{ACC}$	gesehen.
2)				netten$_{ACC, DAT, GEN, PL}$	Dame$_{DAT}$	der Junge$_{NOM}$	geholfen.
	Yesterday	has	the	nice	[1]guy/[2]lady	the boy	seen/helped
3)	Gestern	hat	den	netten$_{ACC, DAT, GEN, PL}$	Typ$_{ACC}$	der Junge$_{NOM}$	gesehen.
4)					Typen$_{DAT}$	der Junge$_{NOM}$	geholfen.
	Yesterday	has	the	nice	[3]guy/[4]guys	the boy	seen/helped

	D		A		N	
1)	der$_{NOM.M.SG}$:	[+M]	nette$_{NOM.M.SG, NOM/ACC.N/F.SG}$:	[ø]	Typ$_{M.SG}$:	[+M]
2)	der$_{DAT.F.SG}$:	[+OBL ⋁ +F]	netten$_{ACC.M.SG, DAT, GEN, PL}$:	[[+OBJ, +M] ⋁ +OBL ⋁ +PL]	Dame$_{F.SG}$:	[+F]
3)	den$_{ACC.M.SG}$:	[+OBJ, +M]	netten$_{ACC.M.SG, DAT, GEN, PL}$:	[[+OBJ, +M] ⋁ +OBL ⋁ +PL]	Typ$_{M.SG}$:	[+M]
4)	den$_{DAT.PL}$:	[+OBJ, +OBL, +PL]			Typen$_{M.PL}$:	[+OBJ, +OBL, +PL]

Table 1: Specifications of determiners (D), adjectives (A) and nouns (N) according to Bierwisch (1967) in square brackets.

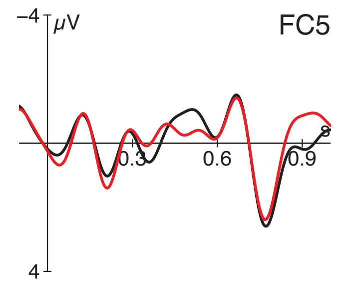

Figure 1: ERP effects observed on FC5 between 300 and 400 ms for D1/2 (black) and D3/4 (red). The time window spans from 200 ms before determiner-onset to 1200 ms after (onset at vertical bar). Negativity is plotted upwards.

Table 2: Determiner (D) effects of ANOVAs of lateral electrode sites of the 300-400 ms latency window.

	effect	df	lateral *F*
D1/2 vs. D3/4	COND	1,18	8.23*
	COND x ROI	3,54	0.52

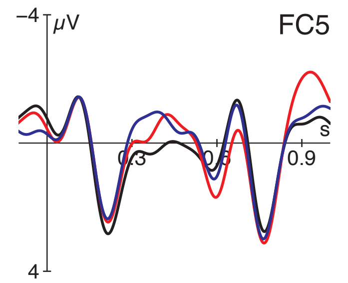

Figure 2: ERP effects observed on FC5 between 350 and 450 ms for A1 (black), A2 (red) after D1/2 and A3/4 (blue) after D3/4. The time window spans from 200 ms before noun-onset to 1200 ms after (onset at vertical bar). Negativity is plotted upwards.

Table 3: Adjective (A) effects of ANOVAs of lateral electrode sites of the 350-450 ms latency window.

	effect	df	lateral *F*
Omnibus ANOVA	COND	2,36	9.54***
	COND x ROI	6,108	2.57 m.s.
A1 vs. A2	COND	1,18	18.67***
A1 vs. A3/4	COND	1,18	12.33**
A2 vs. A3/4	COND	1,18	0.11

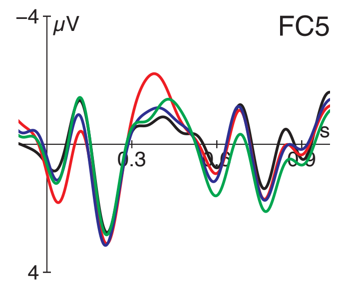

Figure 3: ERP effects observed on FC5 between 300 and 500 ms for N1 (black) after A1 (after D1/2), N2 (red) after A2 (after D1/2) and N3 (blue) and N4 (green) after A3/4 (after D3/4). The time window spans from 200 ms before noun-onset to 1200 ms after (onset at vertical bar). Negativity is plotted upwards.

Table 4: Noun (N) effects of ANOVAs of lateral electrode sites of the 300-500 ms latency window.

	effect	df	*F*	lft. ant. *F*	rgt. ant. *F*	lft. post. *F*	rgt. post. *F*
Omnibus ANOVA	COND	3,54	0.55 n.s.				
	COND x ROI	9,162	4.16***	2.8*	0.87	0.53	1.29
N1 vs. N2	COND	1,18		11.71**			
N1 vs. N3	COND	1,18		–			
N1 vs. N4	COND	1,18		–			
N2 vs. N4	COND	1,18		–			
N3 vs. N4	COND	1,18		–			

Ø to D	**D to A**	**A to N**
Ø to D1: $\#x_{D1} = 1$	D1/2 to A1: $\#x_{A1} = 1$	A1 to N1: $\#x_{N1} = 0$
Ø to D2: $\#x_{D2} = 2$	D1/2 to A2: $\#x_{A2} = 3$	A2 to N2: $\#x_{N2} = 1$
Ø to D3: $\#x_{D3} = 2$	D3/4 to A3/4: $\#x_{A3/4} = 2$	A3/4 to N3: $\#x_{N3} = 1$
Ø to D4: $\#x_{D4} = 4$		A3/4 to N4: $\#x_{N4} = 3$

Table 5: Cardinalities according to $\#(\overline{A} \cap B)$ *→ "low".*

Bierwisch, M. (1967). Syntactic Features in Morphology: General Problems of So-called Pronominal Inflection in German. In *To honor Roman Jakobson: Essays on the Occasion of his seventieth Birthday, 11 October 1966* (Vol. 1, pp. 239–270). Mouton.

Opitz, A., Regel, S., Müller, G., & Friederici, A. D. (2013). Neurophysiological evidence for morphological underspecification in German strong adjective inflection. *Language*, *89*(2), 231–264.

Opitz, A., & Pechmann, T. (2014). Lexical representations of nouns in German rely on underspecified gender features: Psycholinguistic evidence for global underspecification. In A. Assmann, S. Bank, D. Georgi, T. Klein, & E. Zimmermann (Eds.), *Linguistische Arbeitsberichte 92* (pp. 235–262). University of Leipzig.

Opitz, A., & Pechmann, T. (2016). Gender Features in German: Evidence for Underspecification. *The Mental Lexicon*, *11*(2), 216–241.