

## The acceptability, processing and neural signature of nominal gradability

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**Introduction:** There is a dearth of studies investigating semantic Event-Related Potentials (ERP) effects in adjectives. To meet this gap, our study compares nouns to adjectives. It combines formal semantic theorizing with psycho- and neurolinguistic experimentation to test the hypothesis that acceptability and processing of nominal predicates in comparison constructions (“more P”) is predicted by the ease of shift toward an interpretation based on **dimension counting**.

Categorization research reveals prevalence of dimension counting in classification under adjectives like *conservative/liberal* or *optimistic/pessimistic*, which can relate to politics, religion, sex, family, dress code, music, theoretical views, or some or all of those together (cf. Bartch 1986). According to Sassoon (2017), classification under such multidimensional adjectives is based on a **counting scale** reflecting the number of dimensions whose norms each entity exceeds. With a maximal/relative standard of membership, *x is optimistic* is true iff *x* is within the normal range of all/many optimism dimensions, and *x is more optimistic than {y, pessimistic}* is true iff *x* is *optimistic* in more respects than the number of respects in which {*y* is optimistic, *x* is pessimistic}.

As for nouns, dimension counting, although not as common as in multidimensional adjectives, is possible, especially in social nouns – labels of human traits or human-made objects (e.g., *linguist, scarf*). It is rare in natural-kind nouns (e.g., *duck, oak*; Hampton et al. 2009). Classification under natural-kind nouns is based on a causal model of the world (e.g., Gelman 2003). The absence of one dimension can cast doubt on the presence of the underlying cause and thus nullify all the other dimensional contributions. Thus, a donkey with some zebra property is classified neither as a zebra nor as a donkey. This can be modeled using multiplicative averaging, where *x is a donkey* is true iff *x*’s averaged degree of similarity to the prototype in the dimensions of *donkey*, **the weighted product** of its dimensional degrees,  $f_1(\mathbf{x})^{w_1} \times \dots \times f_n(\mathbf{x})^{w_n}$ , is above a norm. Any low degree (e.g., 0 or ½) reduces the product significantly (e.g., Medin & Schaffer 1978; Estes 2004).

By contrast, in social nouns the causal connections between dimensions (e.g., *intended vs. actual function*) are much looser. Each dimension has a constant additive effect on classification; e.g., typically, a linguist works in linguistics departments, investigates languages, and reads Chomsky’s work, but a person violating some of these features may still count as a linguist. Thus, *x is a linguist* is typically modeled as true iff *x*’s **weighted sum** of degrees in the dimensions,  $w_1 f_1(\mathbf{x}) + \dots + w_n f_n(\mathbf{x})$ , is above norm. One 0 degree hardly affects the sum (Rosch & Mervis 1975; Tversky 1977; Hampton et al. 2009). Significantly, upon a shift to equally important dimensions and binary dimensional scales consisting of 1 and 0, **additive (but not multiplicative) dimension-integration reduces to dimension-counting**: classification in social nouns may depend on whether entities were within the norm in *sufficiently many* dimensions (Wattenmaker 1995).

The dimension-counting hypothesis **contrasts** with the view that grammar and conceptual structure (dimension-integration) are dissociated, where mainly the mere lexical category or semantic-type of adjectives rather than nouns matters (e.g., *\*birdier; #more bird than that one*; Kennedy 1999; Baker 2003; Neeleman et al. 2004), especially views that deny the role of dimension counting in gradability. Intuitively, rather than counting dimensions of multidimensional adjectives, speakers weigh the dimensions by importance and sum up the entities’ weighted degrees in those dimensions thus creating one complex dimension (Bylina 2013; Kennedy 2013; Lassiter 2015, a.o.), i.e. adjectives resemble nouns conceptually differing mainly in syntax/type.

**Predictions:** The dimension-counting hypothesis predicts that in comparatives (A) a higher acceptability of multidimensional adjectives stems from their readily available dimension-counting scales, (B) additive nouns whose interpretation may shift to dimension-counting would be judged more acceptable than multiplicative nouns, but the shift will exert processing time. Moreover, since conceptual violations typically engender an N400 ERP effect, while syntactic violations (among others) evoke a P600 effect (Bornkessel & Schlesewsky 2006; Friederici 2004), we expect the behavioral effect predicted in (A) to engender a P600 effect for comparatives with nouns vs. adjectives, and the effect in (B) to engender a more pronounced N400 effect for comparatives with multiplicative-natural-kind nouns relative to additive-social nouns.

**Stimuli:** Eight conditions (0-7) with 40 sentences each and 80 fillers were prepared. Subjects and predicates were balanced for length, frequency, morphological complexity and specificity.

		Comparison	Baseline
Adjectival	Nat	(0) <i>Leumat  ha-toref  ha-hu , ha-toref  ha-ze  yoter amic</i> ; Compared to that predator, this predator is more <b>brave</b> .	(4) <i>Ha-toref  ha-ze  amic</i> ; ‘This predator is <b>brave</b> ’.
	Social	(1) <i>Leumat  ha-hoker  ha-hu , ha-hoker  ha-ze  yoter  macliax</i> ; ‘Compared to that researcher, this researcher is more <b>successful</b> ’.	(5) <i>Ha-hoker  ha-ze  macliax</i> ; ‘This researcher is <b>successful</b> ’.
Nominal	Nat	(2) <i>Leumat  ha-toref  ha-hu , ha-toref  ha-ze  hu  yoter arie</i> ; ‘Compared to that predator, this predator is more <b>a lion</b> ’.	(6) <i>Ha-toref  ha-ze  hu  arie</i> ; ‘This predator is <b>a lion</b> ’.
	Social	(3) <i>Leumat  ha-hoker  ha-hu , ha-hoker  ha-ze  hu  yoter biolog</i> ; ‘Compared to that researcher, this researcher is more <b>a biologist</b> ’.	(7) <i>Ha-hoker  ha-ze  hu  biolog</i> ; ‘This researcher is <b>a biologist</b> ’.

**Participants** were 29 healthy right-handed native Hebrew speakers (age range 18- 33).

**Procedure:** The stimuli were presented in a word by word reading paradigm followed by a naturalness judgment task (1-5-point scale). ERPs (mean amplitude and peak amplitude) were analyzed using 5-way ANOVA with Location (anterior/posterior), Laterality (left/central/right), Structure (baseline/comparison), Predicate (nominal/adjectival) and domain of subject (natural-multiplicative/social-additive) in time windows 325-500ms (N400) and 600-800ms (P600).

**Results and discussion:** Predictions A-B were born out by both the behavioral and ERP data. First, **naturalness ratings** for adjectives were high in both comparative and basic forms, while nouns were rated less acceptable in comparatives. In comparatives only, additive-social nouns manifested higher acceptability over multiplicative-natural-kind nouns. Second, **the RTs** indicated the predicted processing cost for social relative to natural nouns in comparatives, providing evidence for a conceptual dimension counting approach. Speakers easily tap the acceptability of multidimensional adjectives (0-1) and unacceptability of multiplicative natural nouns (2) in comparatives, but spend time on reanalysis to render additive social nouns (3) more acceptable, consistently with the predicted semantic shift to ‘adjectival’ dimension-counting scales. Third, **the ERP analysis** of the P600 window manifested a higher cost for nouns (2-3) than adjectives (0-1) in comparatives, but not in baseline, this is consistent with both a conceptual and syntactic/type view. The N400 window revealed a central posterior cost for processing of multiplicative-natural-kind nouns as opposed to additive-social ones in comparatives, but not in baseline. Such findings are consistent with a conceptual incongruity. Thus, our ERP data further help unravel the nature of violation in “*x is more a duck*”. The evidence is most consistent with a conceptual dimension-counting view (alternatives will be discussed in detail).

**Selected references:** Baker, M.C. (2003). *Lexical Categories*. CUP; Bartsch, R. (1986). Context-dependent interpretations. *GRASS 7*; Bornkessel, I. et al. (2006). *Psych Review 113*(4), 787–821; Bylinina, L. (2013). PhD diss.,

Utrecht; **Estes, Z.** (2004). *Psychonomic Bulletin & Review* 11, 1041–7; **Friederici, A. D.** (2004). *Current Neurology and Neuroscience Reports* 4(6), 466–70; **Gelman, S. A.** (2003). *The essential child*. OUP; **Hampton, A. J. et al.** (2009). *Memory & cognition* 37(8), 1150–63; **Kennedy, C.** (2013). *Inquiry* 56(2-3), 258–77; **Lassiter, D.** (2015). *Handbook of contemp. semantic theory*, 143–67; **Sassoon, W. G.** (2017). *Language* 93(1); **Wattenmaker, W. D.** (1995). *Cog Psy* 28.