Sentence-final particle de in Mandarin as an informativity maximizer

Jun Chen (jun.chen@ling.uni-stuttgart.de) and
Sean Papay (sean.papay@ims.uni-stuttgart.de)
University of Stuttgart

Introduction: East Asian sentence-final particles (SFPs) express a range of subtle, speaker-oriented meanings that pertain to the way the speaker conveys her belief states to the listener (e.g. Chu 1988; Simpson 2014; Constant 2014). The aim of this study is to motivate employing game-theoretic pragmatic methods such as cross-entropy (as a part of the Rational Speech Act model) (Shannon 1948, Jäger 2007, Goodman & Stuhlmüller 2012) as a way to obtain a fine-grained understanding of the non-literal meaning contributions expressed by these particles. We take the Mandarin Chinese particle *de* as an illustration: We first argue *de* serves as a means for the speaker to maximize informativity, marking *de*'s prejacent as maximally informative given a conversational goal. We then show that cross-entropy allows for a formally precise modeling of the notion of informativity as conveyed in the speaker's message.

New data: Mandarin SFP *de* optionally attaches to a complete resolving answer that fully addresses the current Question Under Discussion with the speaker providing complete knowledge:

(1) QUD: Who should I find if I want to get a refund this week?
(zhe zhou) shi cai laoshi fuze baoxiao (**de**).
this week COP Cai teacher handle refund DE
'For this week, it is teacher Cai who handles refunds.'

The speaker with complete knowledge may also address the QUD by supplying multiple contrastive partial answers (each addresses a subquestion within the QUD). In such case the placement of *de* favors the partial answer that covers a larger number of situations, and disfavors the answer partitioning fewer situations.

(2) QUD: Who should I find if I want to get a refund this week?
{Zhouer yizhi dao zhouwu}/ {tongchang}, shi Wang laoshi fuze baoxiao
{Tuesday all.the.way until Friday}/ usually COP Wang teacher handle refund
(**de**); {zhouyi}/ {ou'er}, shi cai laoshi fuze baoxiao ($^{??}$**de**).
DE; Monday/ occasionally, COP Cai teacher in.charge refund DE
From Tuesday until Friday/Usually teacher Wang handles refunds; On Monday/ Occasionally, teacher Cai handles refunds.'

Our preliminary acceptability judgment task (on a 7-point Likert scale, 21 native speakers, 8 target items) revealed that (see Fig.1) when partial answers (i.e. two partial sentences) are juxtaposed, judgments are significantly better with *de* attached to the 'mostly/more workdays' partial answer (than the 'occasionally/fewer workdays' one). The order of the two answers does not matter statistically, excluding the possibility that the contrast is simply a result of the preference for uttering more informative information first and less informative information next.

When the speaker has only incomplete information that addresses the current QUD, she may attach *de* to a partial answer as long as she conveys with it all she knows. Thus, an answer of the form *On Monday/Occasionally, teacher Cai handles refunds* **de**. *I don't know about the rest of the week.* is felicitous. In sum, the generalization of the above pattern is that *de* signals maximal informativity: It indicates the speaker is supplying the answer within her knowledge that is (intuitively speaking) the most informative for satisfying the hearer's conversational goal. This

Condition	Position of *de*	mean values
a.	Tue--Fri/usually *de* < Mon/occasionally	6.331
b.	Mon/occasionally < Tue--Fri/usually *de*	5.797
c.	Tue--Fri/usually < Mon/occasionally *de*	4.631
d.	Mon/occasionally *de* < Tue--Fri/usually	4.422

n.s. ** ***

Figure 1: Only English translation is provided, '$<$' = linear precedence. (a) thus reads as: *"From Tuesday until Friday, Wang handles refunds* **de**. *On Monday, Cai handles refunds."* An ordinal mixed effect model (Christensen 2019) is adopted. '***': p <0.001; '**': p <0.01; 'n.s.': not significant.

applies to an answer (complete or partial) where the speaker says all she knows, as well as to an answer that the speaker knows is more informative than its alternatives.

Analysis: The characterization of *de* as an informativity maximizer is not the same as the notion of informativity defined in terms of (truth-conditional) entailment relations. We propose an information-theoretic formulation, specifically via cross-entropy. The following components are needed: **a)** a set $\mathcal{T}$ of all possible worlds (or equivalence classes of worlds, where two worlds are equivalent if they answer the QUD in the same way); **b)** a speaker, who holds a belief state $P_s(t)$ over worlds $t \in \mathcal{T}$ that she would like to convey; and **c)** a listener, who forms a belief state $L(t|m)$ over worlds $t \in \mathcal{T}$, dependent on some message m . Informativity thus could be measured as the amount of information provided about the speaker's belief state, which is the negated cross-entropy (Shannon 1948) between the speaker's and listener's belief states after the speaker communicates message m, i.e. $\sum_{t\in\mathcal{T}} P_s(t) \log L(t|m)$. Utterances which bring the listener's belief state closer to the speaker's have a higher informativity, while utterances which contradict worlds deemed possible by the speaker have a negative infinite informativity. Utterances which maximize informativity globally are those with cross-entropy equal to the entropy of P_s.

Illustrating with example (2), let $\mathcal{T}$ be the set of all who's-in-charge assignments, each such assignment mapping one day of the workweek to one of the two people who handle refunds. Let $P_s(t) = \delta_{t,s}$, where $s \in \mathcal{T}$ is the unique world described in example (2) i.e. the speaker has perfect knowledge of world s. Finally, let $L(t|m)$ be the uniform distribution over all worlds consistent with the literal meaning of m, i.e. a literal listener with a uniform prior over worlds. From this, the informativity of a message m is $\log L(s|m)$. If m is compatible with s, this is the negative logarithm of the number of worlds compatible with m. As logarithms are monotonic, informativity can be measured by counting worlds, where utterances with *more* compatible worlds are *less* informative.

The response featuring *from Tuesday to Friday* is compatible with 2 worlds, and *on Monday* with 16 worlds (thus more uncertain and less informative). The response featuring the quantifier *usually*, assuming it represents *more than half of the weekdays*, is compatible with 16 worlds. The proposition with *occasionally*, assuming a meaning of *at least one weekday*, is compatible with 31 worlds, hence less informative (as it only excludes one possibility). Since the first proposition is more informative than the second, only it can take the SFP *de*.

Extension: Similar information-theoretic approaches promise to capture a broad range of East Asian SFPs across languages that pertain to comparing the interlocutors' belief states. For instance, Japanese *no* encodes a *surprisal* meaning, signaling *no*'s prejacent contradicts the listener's previously held belief (Cook 1990, Yap et al. 2004). *No* can be formulated via a high Kullback-Leibler (KL) divergence, a metric similar to cross-entropy that measures the divergence between the listener's prior and posterior belief states w.r.t. the message of the utterance.

(3) kore-ga oshio-o haitte nai batta na **no**.
this-SBJ salt-ACC add-PROG NEG butter PRT NO

'(Well actually) This is the butter without salt inside.'

References (selected): Constant, Noah. 2014. Contrastive Topic: Meanings and Realizations. **Jäger, Gerhard**. 2007. Game dynamics connects semantics and pragmatics. **Goodman** and **Stuhlmüller**. 2013. Knowledge and implicature: Modeling language understanding as social cognition. **Shannon, Claude**. 1948. A mathematical theory of communication.