Short Communication: Direct versus indirect causation as a semantic linguistic universal: Using a computational model of English, Hebrew, Hindi, Japanese and K'iche' Mayan to predict grammaticality judgments in Balinese.

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The aim of this study was to test the claim that languages universally employ morphosyntactic marking to differentiate events of more- versus less-direct causation, preferring to mark them with less- and more- overt marking respectively (e.g., *Somebody broke the window* vs *Somebody MADE the window break*; **Somebody cried the boy* vs *Somebody MADE the boy cry*). To this end, we investigated whether a recent computational model which learns to predict speakers' by-verb relative preference for the two causatives in English, Hebrew, Hindi, Japanese and K'iche' Mayan is able to generalize to a sixth language on which it has never been trained: Balinese. Judgments of the relative acceptability of the less- and more-transparent causative forms of 60 verbs were collected from 48 native-speaking Balinese adults. The composite crosslinguistic computational model was able to predict these judgments, not only for verbs that it had seen, but also – in a split-half validation test – to verbs that it had never seen in any language. Clearly, this is only possible if Balinese conceptualizes directness of causation in a similar way to these unrelated languages. Thus, the present findings constitute support for the view that the distinction between more- versus less-distinct causation constitutes a morphosyntactic universal.

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Human languages allow their speakers to express any concept they can conceive of. But some concepts are apparently so ubiquitous in human experience that languages afford them dedicated morphosyntactic constructions. Consider the example of causation, which boasts a dedicated construction in most — perhaps even all — languages (e.g., Nedjalkov, 1969; Comrie, 1976; Comrie & Polinsky, 1993; Haspelmath, 1993; Dixon, 2000). English speakers do not need to use an awkward circumlocution like *André hit the window, which caused it to break*. Instead, they can use their language's *transitive causative* construction to say *André broke the window*. So ubiquitous, in fact, is human discussion of causation that many languages — Shibatani and Pardeshi (2002) list 38 examples¹ — offer their speakers not one but two dedicated causative constructions, which express different degrees of causation.

For example, in addition to the *transitive causative* construction, English has the *periphrastic causative* construction (e.g., *André made the window break*). As its name implies, this construction denotes a more indirect, roundabout kind of causation than the *transitive causative*. For example, if André deliberately hit the window with a hammer, it would be much more natural to say *André broke the window* than *André made the window break*. But if André startled the window fitter, causing him to drop the glass, it would be much more natural to say *André made the window break* than *André broke the window*. Indeed, some verbs/events require a direct cause to such an extent that they more-or-less prohibit the less-direct causative (e.g., *Someone stole the jewellery*; **Someone made the jewellery steal*). Others are so resistant to direct causation that they more-or-less prohibit the more-direct causative (e.g., *Someone made the cry*; **Someone cried the boy*).

One of the most comprehensive typological summaries of the way that languages differentiate more- and less-direct causative types is provided by Dixon (2000), as summarized in Table 1 (see also Comrie, 1981; Song, 1996; Talmy, 2000).

Parameter	Meaning		Mechanism		Language
	Causative type 1	Causative type 2	Causative Type 1	Causative Type 2	
1	state	action	Morphological ₁	Morphological ₂	Amharic
			Morphological	Periphrastic	Bahasa Indonesian, Malay
2	intransitive	all transitive	Morphological	Periphrastic	Austronesian languages, Mayan languages, etc.
	intransitive and simple transitive	ditransitive	Morphological	Periphrastic	Basque, Abkhaz
3	causee lacking control	causee having control	Lexical	Morphological	Japanese
			Morphological ₁	Morphological ₂	Creek
4	causee willing	causee unwilling	Morphological ₁	Morphological ₂	Swahili
			Morphological	CPeriphrastic	Tangkhu Naga
			Morphological	Periphrastic	Swahili
5	causee partially affected	causee fully affected	Morphological ₁	Morphological ₂	Tariana
6	direct	indirect	Morphological ₁	Morphological ₂	Nivkh, Apalaí, Hindi, Jingpaw
			Morphological	Periphrastic	Buru, Chrau, Alamlak,

					Mixtec, Korean
7	intentional	accidental	Morphological	CPeriphrastic	Kammu
			Periphrastic	Morphological plus Periphrastic	Chrau
8	naturally	with effort	Lexical	Morphological	Fijian
			Lexical	Periphrastic	English
			Morphological	Periphrastic	Russian, Tariana

Although there has been a great deal of debate as to how best to characterize the two different causative types (we summarize them simply as “more direct” and “less direct”, corresponding to Dixon’s Type 1 and Type 2 respectively), the claim that languages universally mark such a distinction morphosyntactically enjoys considerable typological support. However, to our knowledge no study (except, in part, the study of Ambridge et al, 2020, summarized below) has tested this claim experimentally.

The aim of the present study is therefore to test a version of this claim; specifically, the claim that actions that are amenable to more- and less-direct causation tend, across languages, to strongly prefer what Shibatani and Pardeshi (2002) term *less-transparent* and *more-transparent* causative forms respectively. We do so by investigating whether a recent computational model which learns to predict speakers’ by-verb relative preference for the two causatives in English, Hebrew, Hindi, Japanese and K’iche’ Mayan (Ambridge et al, 2020) can generalize to a sixth language, on which it has never been trained: Balinese.

Ambridge et al (2020) tested the particular formulation of this *semantic-universal* hypothesis set out by Shibatani and Pardeshi (2002: 89), though the general idea dates back at least as far as Fodor (1970), Givon (1979) and Hopper and Thompson (1980):

- **Less-direct causation** entails an event in which “both the causing and the caused event enjoy some degree of autonomy...The caused event... may have its own spatial and temporal profiles distinct from those of the causing event”, and hence is associated with ***more-transparent causative marking*** (e.g., the English *periphrastic causative* construction, in which some form of the verb MAKE serves as a transparent causative marker, similar, for example to Hindi *-aa* or Japanese *-(s)ase*).

- **More-direct causation** “entails a spatio-temporal overlap of the causer’s activity and the caused event, to the extent that the two relevant events are not clearly distinguishable”, and hence is associated with ***less-transparent causative marking*** (e.g., the English *transitive causative* construction, which lacks a transparent causative marker such as MAKE, similar, for example to so-called lexical-causatives in Hindi or Japanese).

Ambridge et al asked 20 native adult speakers of each language to rate 60 causative events – shown as unlabelled animations – for the extent to which they exhibit this property of *Event-Merge*, as well as three further relevant properties set out by Shibatani and Pardeshi (2002): (a) *Autonomy* of the causee, (b) whether the caused event *Requires* a causer, and (c) whether causation is *Directive* (e.g., giving an order) or physical. The authors then trained a distributional-learning computational model to predict the most probable of two causative forms for each of 60 corresponding verbs, presented in proportion to their frequency in suitable corpora for each language (non-causative forms in the corpus were mapped to an “Other” construction). Verbs were presented to the model as an orthogonal “lexical” vector, alongside their semantic properties as determined by the human semantic rating task. The

model was then tested on its ability to predict participants' relative preference for the more- versus less-transparent causative construction for each verb, as obtained using a second judgment task with new adult participants. Even though the model was never presented with any grammaticality judgment data, it successfully learned to predict participants' judgments with correlations of around $r=0.75$. Importantly, the semantic information learned by the model allowed it to show similar performance on a split-half validation task consisting of verbs on which it had never been trained.

Ambridge et al (2020) built separate computational models for each language. However, if it is indeed the case that languages are highly similar in the way that they carve up semantic space into events of more-direct and less-direct causation, a composite model trained using semantic and frequency data from English, Hindi, Hebrew, Japanese and K'iche' Mayan should be able to make a reasonable stab at predicting human grammaticality judgments from a different language altogether. Here, we test this claim using Balinese.

Although an important motivation for choosing Balinese was of course the availability of native-speaking participants and researchers, Balinese is highly suitable for our purposes given that, as an Austronesian language, it belongs to a different family to all five of the languages used to train the model. Thus, we can be confident that the predicted effect, if found, reflects the fact that Balinese has independently developed more- and less-direct causative constructions along the continuum posited, rather than having inherited these constructions from one or more of our training languages.

Despite having a relatively small number of native speakers, Balinese is well documented in terms of the relevant morphosyntactic properties (e.g., Shibatani & Artawa, 2015). Similar to English, more-transparent "indirect causation...calls for a periphrastic construction with the causative verb derived from the verb *ngranang* 'make'" (p.926)

(1) *Anak ento ngranang anak-e cenik ngeling*
 Someone that made person-DEF small cry
 'Someone made the child cry'

Again, similar to English, verbs denoting actions that are amenable only to relatively indirect causation (e.g., *ngeling*, 'cry') require this *periphrastic causative* and resist the standard *transitive causative* (which, in Balinese, requires the causative marker *-ang*)

(2) *Anak ento ngeling-ang anak-e cenik*
 *Person that cry-CAUSE person-DEF small
 '*Someone cried the child'

Thus, the goal of the present study was to investigate whether a computational model trained on causatives in English, Hebrew, Hindi, Japanese and K'iche' Mayan could predict Balinese speakers' relative preference for periphrastic versus transitive causatives across 60 verbs.

Method

Computational Model

In terms of architecture and parameters, the computational model was identical to each of the language-specific models reported in Ambridge et al (2020), from which the following description is taken:

The input to the model is a vector of 60 lexical units (1/0), a causative unit (1/0) and four semantic units (continuous activation level 0-1). The orthogonal lexical units represent the identity of the verb, and can be conceptualized as a pseudo-phonological representation (e.g. the root /bɔɪl/ for English *boil*) and/or a pseudo-lexical-semantic representation (e.g., “[of a liquid] to heat until it reaches boiling point”). The causative unit (1/0) indicates whether or not the utterance presented to the model on that trial conveys causation. That is, the causative unit is set to 1 if the corpus utterance uses either the more- or less-transparent causative form for the relevant verb (e.g., *The man made the water boil*; *The man boiled the water*) and to 0 if it does not (e.g., *The water boiled*). This unit can be conceptualized as representing, at a very broad-brush level, event-level semantics. The four semantic units, Event-Merge, Autonomy, Directive and Requires, are assigned a continuous activation level based on the mean rating...for the verb in the relevant utterance. These units can be conceptualized as representing some subset of the overall semantics (i.e., verb-level and/or event-level semantics) of the relevant utterance. Finally, the orthogonal output units (with softmax activation function) are each set to 1 or 0 representing the form/utterance type of the relevant corpus utterance: More transparent (e.g., *The man made the water boil*), Less transparent (*The man boiled the water*) or Other (e.g., *The water boiled*).

The composite model built here differs from the language-specific models reported in Ambridge et al (2020) in two respects. First, the relative frequency with which each “utterance” was presented to the model was determined not on the basis of not a language-specific corpus, but of a composite corpus created by randomly sampling 300,000 utterances from each of the English, Hebrew, Hindi, Japanese and K’iche’ corpora (although, as in Ambridge et al, 2020, only 10,000 randomly-sampled utterances were used for each model run). Second, and similarly, the continuous activation levels of the semantic units for each verb were determined not on a language-specific basis, but by taking the mean rating across all 100 participants who completed the semantic rating task; 20 per language.

Ethics

The study was approved by the ethics committee of Udayana University, Bali, Indonesia. All participants gave informed consent.

Participants

Forty-eight native Balinese speaking adults took part in the grammaticality judgment task. Although formal language data were not collected, like all Balinese speakers, these participants would have been fluent speakers of Indonesian, and most would have had basic level knowledge of English.

Materials and Procedure

Participants rated the grammatical acceptability of 120 sentences presented by the experimenter in random order, using PsychoPy2 (Peirce, Gray, Simpson, MacAskill, Höchenberger, Sogo, Kastman & Lindeløv, 2019): Each sentence included a more-transparent (*ngranang*, ‘make’ periphrastic) or less-transparent (transitive) causative form of one of the same 60 verbs (in translation) used in Ambridge et al (2020), with *Anak*, ‘someone’ as the subject (e.g., 1-2). Each sentence was accompanied by an animation in

which the caused event, but not the causer, was visible; the same animations used by Ambridge et al (2020) for all languages, for both the grammaticality judgment and semantic ratings tasks (downloaded from <https://osf.io/69ehu/>). Participants rated the acceptability of each sentence using a computerized 5-point smiley-face Likert-type scale (designed originally for use with children).

Results

Mean ratings of the acceptability of the more-transparent (periphrastic) and less-transparent (transitive) causative forms of each verb are shown in Figure 1, alongside the corresponding adult data from English, Hindi, Hebrew, Japanese and K'iche' Mayan (note that these figures did not appear in Ambridge et al, 2020, but have been created using the raw data available at <https://osf.io/69ehu/>). Visual inspection of Figure 1 suggests that, as predicted by the semantic-universal hypothesis, Balinese is generally similar to these other languages with regard to verbs' preferences for more- versus less-transparent causative forms (although these preferences seem somewhat weaker in Balinese).

Figure 1. Participants ratings for more- and less-transparent causative forms of 60 verbs (in translation equivalent) in Balinese (present study), English, Hebrew, Hindi, Japanese and K'iche' (data from Ambridge et al, 2020).

In order to test this prediction in more detail, we investigated whether our computational model trained on causatives in English, Hebrew, Hindi, Japanese and K'iche' Mayan could predict Balinese speakers' relative preference for the two forms of each verb. We did so by conducting simple model-human Pearson calculations for each epoch of the model, in each case taking the mean rating for each verb across all 48 Balinese-speaking

participants and 48 runs of the model. The results of this analysis are shown in Figure 2 for (a) difference scores (preference for less- over more-transparent causative form), and raw ratings for (b) less-transparent (transitive causative) and (c) more transparent (periphrastic causative) forms. The bottom half of the figure shows how the crosslinguistic model's preference for more- versus less-transparent causative forms changes across development, simulating both children's overgeneralization errors with less-transparent causative forms, and the fact that such errors are virtually absent for more-transparent causative forms (e.g., Bowerman, 1988).

Figure 2. Correlation between predictions of composite crosslinguistic model's and Balinese speakers' acceptability judgments for (a) difference scores (preference for less-over more-transparent causative form), and raw ratings for (b) less-transparent (transitive causative) and (c) more transparent (periphrastic causative) forms

Looking at difference scores, which Ambridge et al (2020) argued constitutes “in many ways the fairest test of the model, which...makes relative rather than absolute predictions regarding the acceptability of the more- and less-transparent causative forms”, the model achieves a respectable, medium-sized correlation of around 0.5 (by around 15 epochs). This is short of the within-language calculations reported by Ambridge et al (mainly around $r=0.75$), but is still comfortably statistically significant, even at the more stringent $p<0.01$ cutoff (Critical r ($df=58$) value for $p<0.05 = 0.21$; for $p<0.01 = 0.30$ (one-tailed test)).

Even more impressively, this correlation is maintained in a split-half validation test in which the model's task is to predict acceptability judgments for verbs it has never seen (in any language) during training (30/60 verbs, selected at random for each of the 48 model runs at each epoch). That is, the previous analysis demonstrates that a model trained on the English, Hindi, Hebrew, Japanese and K'iche' equivalents of (for example) *come* and *break* can predict the relative acceptability of the Balinese periphrastic- and transitive-causative forms of *come* and *break*. The split-half validation test demonstrates that a model trained on the English, Hindi, Hebrew, Japanese and K'iche' equivalents of (for example) *come* and *break* can predict the relative acceptability of the Balinese periphrastic- and transitive-causative forms of (for example) *cry* and *cut*. The model achieves this feat by learning which semantic features – the four human-derived measures of directness of causality – are predictive of more- and less-transparent forms in the composite corpus, allowing it to make predictions for unseen verbs on the basis of their semantics, even in an unseen language.

Inspection of the raw score correlations shows how the English...K'iche' model achieves its correlations with Balinese speakers' preferences for less- over more-transparent causative forms: by predicting their ratings for less-transparent but not more-transparent causative forms. This is probably because, as shown in Figure 1, in Balinese periphrastic causative forms are relatively acceptable across the board; more so, in fact, than for any of the other five languages.

Discussion

A well-supported claim in the typology literature holds that languages universally employ morphosyntactic marking to differentiate – at a broad-brush level – events of more- versus less-direct causation, preferring to mark them with less- and more- overt marking respectively. However, to our knowledge, no previous study has tested this claim experimentally. In the present study, we did so by investigating whether a recent computational model which learns to predict speakers' by-verb relative preference for the two causatives in English, Hebrew, Hindi, Japanese and K'iche' Mayan is able to generalize to a sixth language on which it has never been trained: Balinese.

In fact, this composite English...K'iche' model was able to predict the relative acceptability not only of translational equivalent verbs in Balinese, but even – in a split-half validation test – to verbs that it had never seen in any language. That is, the model was learning which semantic properties predict corpus occurrences of more- versus less transparent causative marking universally (or, at least, across five typologically unrelated languages), and using them to predict the acceptability of causative forms in an untrained language. It is therefore hard to imagine an experimental study of a single language yielding stronger evidence in support of the semantic-universal hypothesis.

References

- Ambridge, B., Maitreyee, R., Tatsumi, T., Doherty, L., Zichermann, S., Pedrom, P. M., Bannarda, C., Samanta S., McCauley, S., Arnold I., Bekmand, D., Efratid, A., Bermann, R., Narasimhan, B., Sharmag, D.M., Nairh, R. B., Fukumurai, K., Campbell, S., Pyel, C. (2020). The crosslinguistic acquisition of sentence structure: Computational modeling and grammaticality judgments from adult and child speakers of English, Japanese, Hindi, Hebrew and K'iche'. *Cognition*, 202, 104310

- Bowerman, M. (1988). The “no negative evidence” problem: How do children avoid constructing an overly general grammar? In J.A. Hawkins (Ed.). *Explaining language universals*. Oxford: Blackwell pp. 73-101
- Comrie, B. (1981). *Language Universals and Linguistic Typology: Syntax and Morphology*. Chicago: University of Chicago Press. p.158–177.
- Comrie, B. (1976). The syntax of causative constructions: Cross-language similarities and divergences. *Syntax and Semantics*, 6 (1976), pp. 261
- Comrie, B & Polinsky, M. (Eds.). (1993). *Causatives and transitivity* (Vol 23). Amsterdam: John Benjamins,
- Dixon, R.M.W (2000). A typology of causatives: form, syntax and meaning. In *Changing Valency: Case Studies in Transitivity*, Dixon, R.M.W. and Alexandra Y. Aikhenvald, eds. New York: Cambridge University Press. p.30–83.
- Fodor, J.A. (1970). Three reasons for not deriving ‘kill’ from ‘cause to die’ *Linguistic Inquiry*, 1 (4) (1970), pp. 429-438
- Givón, T. (1979). *On Understanding Grammar*. New York: Academic Press
- Haspelmath, M. (1993). More on the typology of inchoative/causative verb alternations. In B. Comrie & M. Polinsky (Eds). *Causatives and transitivity. Studies in Language Companion Series*. Amsterdam: John Benjamins.
- Hopper, P., & Thompson, S. A. (1980). Transitivity in Grammar and Discourse. *Language*, 56, 251-299.
- Nedjalkov (1969). Nekotorye verojatnostnye universalnii v glagol'nom slovoobrazovanii I.F. Vardul (Ed.), *Jazykovye universalii i lingvisticheskaja tipologija*, Nauka, Moscow (1969), pp. 106-114
- Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior Research Methods*, 51 (1), 195-203.
- Shibatani, M., & Artawa, K. (2015). Valency classes in Balinese. In Malchukov, A. & Comrie, B. *Valency classes in the world's languages*. De Gruyter. (pp. 857-920).
- Shibatani, M. & Pardeshi, P. (2002). The causative continuum. In *The Grammar of Causation and Interpersonal Manipulation*, Masayoshi Shibatani (Ed.), pp. 85–126. Amsterdam: John Benjamins.
- Song, J.J. (1996). *Causatives and causation: A universal-typological perspective*. London and New York: Addison Wesley Longman.
- Talmy, L. (2000.) *Toward a Cognitive Semantics* Volume 2: Typology and Process in Concept Structuring. Cambridge: MIT Press. p.67–101.

¹ Ahtna, Alamblak, Amharic, Asheninka, Bella Coola, Burmese, Cantonese, Carrier, Creek, English, French, German, Guaraní, Hualapai, Hungarian, Japanese, Kammu, Kinyarwanda, Korean, Koyukon, Lushai, Malay, Manchu, Mandarin, Marathi, Matses, Navajo, Olutec, Quechua, Shipibo-Konibo, Sikuani, Svan, Tarascan, Tiddim Chin, Turkish, Yidiny, Yimas and Yukaghir.