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Syntactic Representations Contain Semantic Information: Evidence From Balinese Passives

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Semantics-based approaches to syntax hold that the basic units of language are constructions: form-meaning pairings that have meanings in and of themselves. The aim of the present study was to test this claim using a previously-unstudied construction: Balinese passives. Using a grammatical acceptability judgment methodology with 60 native adult speakers, we found that independent ratings of 49 verbs' semantic affectedness (obtained from a separate group of 20 native adult speakers) significantly predict the relative acceptability of these verbs in three types of passives (*-a*, *ka-* and *ma-* passives), and also actives, but not in what we term the "basic passive"; a construction which lacks the morphological markers that characterize the other passive types. These findings constitute support for semantics-based approaches to syntax, but are more difficult to reconcile with approaches that posit a pure-syntax level of representation that includes syntactic category information but not semantic information or lexical content.

Introduction

A central question in the cognitive sciences is the nature of speakers' linguistic representations; in particular, the syntactic representations that allow them to construct sentence-level utterances (e.g., *The man was surprised by the woman*). The goal of this paper is to use psycholinguistic data from an understudied language, Balinese, to bring some evidence to bear on this debate. Although, on the surface, it is hard to imagine a more "niche" topic than Balinese syntax, the debate in this domain is a test case for a wider debate regarding linguistic representations, and a still-wider debate regarding human representations in general; a debate with implications as far-ranging as how best to build self-driving cars (e.g., Marcus, 2018).

The debate is this: Is human knowledge best captured in terms of (a) symbolic categories and deterministic rules for manipulating them or (b) probabilistic knowledge that is built up gradually on the basis of the input? For example, when building an Artificial Intelligence to simulate the knowledge of human drivers, the first approach would define a pedestrian in terms of necessary and sufficient features (e.g., living; human), and specify a number of rules relating to them (e.g., IF pedestrian is in front of vehicle THEN stop; IF pedestrian is on the sidewalk THEN continue). Importantly, these symbolic categories (e.g., pedestrian) and rules (IF…THEN…) are hard-wired into the system (although they may also be finessed by some learning). The second, probabilistic approach eschews hard-wired categories and rules in favour of input-based learning: The information from all of the car's sensors is fed into a giant "deep learning" computational model, which is "rewarded" for successful outcomes (e.g., a safe trip) and "punished" for unsuccessful ones (e.g., hitting a pedestrian). Over time, the model builds internal representations that (hopefully!) *approximate* rules like "IF pedestrian is in front of vehicle THEN stop", but these representations remain fuzzy and probabilistic.

In terms of human linguistic representations, the first approach posits (possibly hard-wired) categories such as Noun Phrase (e.g., *The woman*) and Verb Phrase (*surprised the man*), and rules for combining them into sentences (e.g., Sentence = Noun Phrase + Verb Phrase). The second approach assumes that speakers instead generalize across similar sentences in the input (e.g., *The woman surprised the man; The boy surprised the girl*) and arrive at representations that *approximate* the rule-based ones, but remain fuzzy and probabilistic (often called "constructions").

In the present article, we will call the first approach the "pure syntax" view. In more formal terms, this view sees syntax (roughly speaking, the set of procedures for building sentences) as "a computational system that interfaces with both semantics and phonology but whose functioning (that is the computations that are allowed by the system) is not

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affected by factors external to it" (Adger, 2017, p. 2). This view encompasses both traditional Chomskyan accounts (Branigan & Pickering, 2017; Chomsky, 1993; Culicover & Jackendoff, 2005; Newmeyer, 2003), and "simpler syntax" accounts (Branigan & Pickering, 2017, p. 8; Culicover & Jackendoff, 2005; Pollard & Sag, 1994), all of which posit a "syntactic level of representation [that] includes syntactic category information but not semantic information…or lexical content". For example, a passive utterance such as *The man was surprised by the woman* might be formed using (very approximately) the syntactic representation *[S [NP] [VP [AUX] [V] [PP [P] [NP]]]]* (from Branigan & Pickering, 2017, p. 8). The details of these accounts are not important for our purposes – and, in any case, vary from theory to theory – the point is that they share the assumption that speakers put together sentences using formal rules that make no reference to semantic information; for example, to the meaning of the particular verb used (e.g., *surprised, punched* etc.)

In contrast, what we will call "semantics-based" approaches (e.g., Goldberg, 1995, 2006; Langacker, 2008) assume that sentence-level constructions (like all constructions) are pairings of form and functions. At the form level, these constructions approximate the representations posited by traditional accounts. Importantly, however, each construction is additionally associated with a prototype function or semantics. For example, in the case of the passive construction (e.g., *The man was surprised by the woman*), the associated semantics are such that

> [B] (mapped onto the surface subject [of a passive]) is in a state or circumstance characterized by [A] (mapped onto the by-object or an understood argument) having acted upon it (Pinker et al., 1987).

What this means, in simple terms, is that the prototypical passive sentence is one in which the SUBJECT (usually the first-mentioned entity) is highly *affected* by the relevant action. For example, *The referee was punched by one of the fans* (example from Bock, 1986) is a prototypical passive, because the referee is likely to have been highly affected by having been punched. In contrast, a sentence such as *The referee was remembered by one of the fans* strikes most speakers as somewhat awkward, precisely because – if Pinker et al. (1987) are correct – the referee is unlikely to have been affected at all by this remembering event (indeed, he may well remain entirely oblivious to it). Furthermore, a sentence such as *$10 was cost by the book* (c.f., the active equivalent *The book cost $10*) strikes most speakers as wholly ungrammatical, precisely because – if Pinker et al. (1987) are correct – there is no possible reading under which $10 is "affected" by "having the book cost it". When we refer to degree of *affectedness* in the present article, this is what we mean.

The English passive has long constituted something of a test-case for this debate between *pure-syntax* and *semantics-based* approaches to linguistic representation. The findings of syntactic priming studies with adults and children have generally provided support for the pure-syntax approach. For example, Bock (1986) found that participants were more likely to produce passive than active picture descriptions (e.g., *The church is being struck by lightning* vs *Lightning is striking the church*) after repeating passive, rather than active prime sentences (e.g., *The referee was punched by one of the fans* vs *One of the fans punched the referee*). Subsequent studies have confirmed that this passive priming effect is robust, even in the absence of semantic and/or lexical overlap between the prime and target sentences (as in the examples above). A recent meta-analysis (Mahowald et al., 2016) of 74 individual passive priming studies found an overall log-odds ratio of 0.52, indicating that passives were 1.68 times as likely following a passive versus active prime.

Such findings have generally been taken as evidence for *pure-syntax* approaches (e.g., Branigan & Pickering, 2017), since the priming effect does not appear to require a prime sentence that is consistent with the putative semantics of the construction. For example, Messenger et al. (2012) found no evidence of increased priming following *agent-patient* and *theme-experiencer* primes (e.g., *The man was chased/surprised by the woman*) as opposed to *experiencer-theme* primes (e.g., *The man was missed by the woman*). Semantics-based accounts would seem to predict the presence of such an effect, on the basis that *theme-experiencer* passives are less consistent with the semantics of the *The man* being "in a state or circumstance characterized by… [*The woman*]… having acted upon it". A recent high-powered replication of Messenger et al (Darmasetiyawan et al., 2022) largely supported the original finding: Although the data were, according to a Bayes Factor analysis, more consistent with the presence of a semantic effect than its absence, the observed effect was tiny, compared with a very large overall priming effect.

A number of other findings, on the other hand, would seem to constitute evidence for semantics-based over pure-syntax approaches. Using a modified version of Messenger et al's (2012) method, specifically varying the semantics of the prime rather than target verb, Bidgood et al. (2020) and Ambridge et al. (2021), found that adults and children indeed produced fewer experiencer-theme passives (e.g., *The man was missed by the woman*) than the other types. Bidgood et al. (2020) further showed that this disadvantage for experiencer-theme passives extended to a forced-choice comprehension task; again for both adults and children.

Of more direct relevance to the present study, Ambridge et al. (2016) showed that independent ratings of verbs' "affectedness", designed to capture the putative semantics of the passive construction, predicted the grammatical acceptability of passives in a judgment task. Crucially, while a similar effect was also observed for actives (which also prototypically convey some degree of "affectedness"), the effect was bigger for passives, as revealed by a significant interaction of the semantic affectedness predictor by rated sentence type (i.e., passive/active).

According to the World Atlas of Language Structures, almost half of documented languages (162/373=43%) have a dedicated passive construction (https://wals.info/feature/107A#3/49.04/76.64). Yet all but a handful of the studies discussed above have been conducted in English. Aryawibawa & Ambridge (2018) and Liu & Ambridge (2021) therefore set out to replicate the adult acceptability judgment study of Ambridge et al. (2016) in Indonesian and Mandarin respectively. For Indonesian, the predicted semantic effect

was observed for (canonical) passives (as in Ambridge et al., 2016, a smaller effect was also observed for actives), but not for the so-called "noncanonical" passive, a topicalization construction that follows passive word order, but lacks passive (or active) morphology. A topicalization construction is one that "promotes" a particular noun phrase (e.g., "that dog") to the beginning of the sentence (i.e., to the usual SUBJECT position) in order to establish it as the topic or theme of conversation; i.e., "the thing we're talking about". For example, in English we might say

(I like most dogs but) that dog, I hate
(c.f., the non-topicalized form I *hate that dog*)

For Mandarin, the predicted effect was observed for (canonical) *BEI*-passives (and also *BA*- actives; a dedicated affectedness construction), but – again – not for a noncanonical topicalization construction with passive word order, nor for regular actives.

The aim of the present study is to extend this methodology to investigate the semantics of passive(-like) and active constructions in a fourth language: Balinese. Despite its geographical and linguistic proximity to Indonesian, Balinese is particularly interesting for our purposes, since it has four different passive constructions.

Balinese and Balinese Passives

Balinese belongs to the (West) Malayo-Polynesian language group, and like many west-Indonesian languages, shows remnants of the Austronesian voice system (Artawa, 2013). In common with many languages of this group, the basic unmarked form of the verb in canonical (i.e., "active") word order actually gives a SUBJECT-as-patient meaning. For example, a [SUBJECT] [VERB] [OBJECT] sentence with the unmarked form of *tulud*, 'push' indicates not that the SUBJECT (here, *the man*) pushed the OBJECT (here, *the woman*), but vice versa

Nak muani ento tulud nak luh ento.
person male that push person female that.
(As for) the man, the woman pushed (him)

This "Objective Voice" construction (e.g., Arka, 2003), also called the "Basic Verb" construction (Artawa, 2013), is a relatively marked and unusual construction, which serves the pragmatic function of "fronting" the (would-be) OBJECT (Arka & Simpson, 1998, p. 6). That is, the Balinese sentence above is best translated not as simply "The woman pushed the man" but as "As for the man, the woman pushed him" or "It was the MAN that the woman pushed". Thus although this construction clearly has some passive-like properties, it is usually considered to be a type of active construction (Arka, 2003; Artawa, 2013). At least one analysis, however (Kersten, 1984), treats this construction as a type of passive. In the present study, as detailed below, we use a variant of this Objective Voice/Basic Verb construction which includes a passive-like *by*-phrase (*teken*).

Canonical active (Active Voice) sentences

For the standard active meaning, a canonical [SUBJECT] [VERB] [OBJECT] transitive sentence, at least with an agent-patient verb, usually requires a "nasal prefix replacing the initial consonant" (Arka & Simpson, 1998, p. 6), *n-* (or *ng-*)

Nak muani ento **n**-ulud nak luh ento.
person male that push person female that.
The man pushed the woman.

Passive(-like) sentences

Turning to passives, the most common passive is the ***-a* passive** form, which usually requires a definite, known, volitional agent (Arka & Simpson, 1998; Sujaya et al., 2019), expressed in a *by*-phrase with *teken*.

nak luh ento tulud-**a** teken nak muani ento.
person female that push-PASS by person male that.
The woman was pushed by the man

Arka (2003, p. 7) calls the *-a* passive the "low passive" because it originates in "low register" Balinese (i.e., informal, spoken Balinese, particularly in the mountainous regions), and developed from the third person pronoun *–(n)a*.

***Ka-* passives** are, according to Arka (2003, p. 6) "real passives (originally associated with high register, but currently also used for low register)". Pragmatically, they are often used to emphasize that the activity is non-volitional on the part of the agent Accordingly, the agent is often omitted, unlike for the *-a* passive (Udayana, 2013), though this is by no means obligatory (Arka, 2003).

nak luh ento **ka**-tulud (teken nak muani ento).
person female that PASS-push (by person male that).
The woman was pushed (*by the man*).

Similarly, ***ma-* passives** (which Arka, 2003, p. 242 calls "resultative" or "actorless" passives) are used to emphasize that the subject is an affected patient, with the agent deemed unimportant, and usually omitted (in fact, Arka, 2003, p. 242, goes so far as to say that the verb "does not allow an oblique Agent PP"). Nevertheless, because it is unclear whether this prohibition is categorical – and for consistency with the other passive stimuli – we include a *by*-phrase with *teken* (i.e., an "oblique Agent PP") in our *ma-* passive stimuli.

nak luh ento **ma**-tulud (*?teken nak muani ento).
person female that PASS-push (by person male that).
The woman was pushed (*by the man*).

The *ma-* passive is "resultative" in the sense that it allows "only verbs of high transitivity that give rise to a kind of result (e.g., a product or a transferable thing)…Verbs of 'low' transitivity, such as verbs of perception, do not take ma-" (Arka, 2003, p. 243). This notion of transitivity would seem to overlap with – though is not identical to – the notion of affectedness investigated in the present study. Shibatani & Artawa (2003, p. 240) have argued that some *ma-* forms can be analysed as "middles" (e.g., *The man washed [himself]* or "antipassives" (e.g,. *I ate [the rice]*), though this analysis is somewhat controversial (Arka, 2003, p. 246).

Table 1. Summary of the Balinese constructions investigated in the present study.

	active	*-a* passive	*ka-* passive	*ma-* passive	*Basic* passive
Argument order	Agent-Patient	Patient-Agent	Patient-Agent	Patient-Agent	Patient-Agent
Nasal prefix replaces initial consonant?	Yes	No	No	No	No
Passive morphologically marked	NA	Yes	Yes	Yes	No
by-phrase with AGENT?	NA	Usually required, definite, known, volitional	Often (though not obligatorily) omitted	Usually (possibly obligatorily) omitted	Obligatory
Register	Both	Low	Originally high, now both	Both	Low, informal
Pragmatics	Neutral	Default passive expressing both PATIENT and AGENT	Non-volitional on the part of the AGENT	Resultative for the PATIENT; AGENT is unimportant	Unclear? Arguably "pure" topicalization with no additional "passivizing" function.

The final construction that we include in this study is one that we term the **basic passive**. This follows the same PATIENT-VERB-AGENT order as the Objective Voice/ Basic Verb construction (Arka, 2003; Artawa, 2013) discussed above, but also includes a *by*-phrase (*teken*). That is, this construction follows the same word-order as *-a, ka-* and *ma-* passives, but lacks any kind of morphological marking (note the use of the basic form *tulud*, as opposed to the marked active form *nulud*):

nak luh ento tulud-ø teken nak muani ento.
person female that push by person male that.
The woman was pushed by the man

We have been unable to find any reference to this construction in the literature; only to the Objective Voice/Basic Verb construction (i.e., the version that lacks *teken*, but is otherwise identical). However, the first author – a native speaker of Balinese – considers this basic passive (a term of our own invention) to be grammatically acceptable (an intuition more-or-less borne out by the findings of the present study). Thus, we decided to include this version – rather than the version without *teken* – for consistency with the other passive stimuli.

As the above sketch of passive(-like) constructions in Balinese makes clear (see Table 1 for summary), there is some debate in the linguistics literature regarding exactly which constructions constitute "real" passives. From a psycholinguistic perspective, however, the point is moot: The prediction of the *semantics-based* approach is simply that at least one of these passive(-like) constructions will show a semantic affectedness effect similar to that already observed for English, Indonesian and Mandarin; at least on the assumption that passive(-like) constructions show similar tendencies crosslinguistically.

The present study

Thus the main aim of the present study is to test a prediction that follows from semantics-based approaches to the passive; specifically, that at least one of the *-a, ka-*, *ma-* and basic passive constructions will show a semantic affectedness effect. On the assumption that the SVO active construction is also prototypically associated with affectedness – albeit to a lesser extent than passives – we would also expect the active construction to show an affectedness effect; albeit a smaller one than observed for passives. Otherwise, we make no specific predictions regarding which constructions will show larger or smaller affectedness effects, and take an exploratory approach to statistical analysis.

A complicating factor in the present study (as compared with English, Indonesian and Mandarin) is that since, for consistency, all passives include a *by-* (*teken-*) phrase, we will presumably see lower acceptability ratings for *ka-* and, in particular, *ma-* passives, which disfavour the expression of the agent to a lesser (*ka-*) and greater (*ma-*) degree respectively. Nevertheless, unless such sentences are deemed so ungrammatical as to yield floor effects – this overall lowered acceptability would not seem to preclude semantic affectedness effects for *ka-* and *ma-* passives.

Method

Participants

Sample sizes of N=60 for the grammatical acceptability judgment task and N=20 (different participants) for the semantic rating task were chosen, based on the Indonesian and Mandarin studies of Aryawibawa & Ambridge (2018) and Liu & Ambridge (2021). All participants were native speakers of Balinese attending Udayana University in Bali, Indonesia. Although no formal language measures were taken, it can also be assumed that all participants had some

exposure to Indonesian and English. Ethics approval was granted by the ethics committees of the University of Liverpool (Project Reference 5322) and Udayana University, and all participants gave informed written consent.

Grammatical acceptability judgment task

The grammatical acceptability judgment task was conducted online using the Gorilla.sc platform, and can be reviewed at https://app.gorilla.sc/openmaterials/257204. Forty-nine of the 72 verbs used across Ambridge et al. (2016), Aryawibawa & Ambridge (2018) and Liu & Ambridge (2021) were used, since many of the original 72 (e.g., *listen* and *hear*) translate into a single verb in Balinese (e.g., *dingeh*). Other verbs were dropped because they lack an equivalent single verb in Balinese (e.g., *dress* would be translated as *salukin penganggo*, 'put on clothes'). Each verb appeared in one active and four passive constructions (49x5=245 sentence types)

Active
Nak muani ento **n**-ulud nak luh ento.
person male that push person woman that.
The man pushed the woman.

Passive (-a/ka-/ma/-ø)
nak luh ento [tulud-a/ka-tulud/ma-tulud/tulud-ø] teken nak muani ento.
person woman that [push-PASS] by person male that.
The woman was pushed by the man

An additional 245 sentence types were created by reversing the agent and patient roles (*The man/The woman*) for a total of 490 unique trials (see Table 2 for details). Because this was deemed to be too many trials for a single participant, we created two counterbalance sets, containing (A) 250 trials (25 verbs x 5 sentence types x 2 agent/patient mappings) and (b) 240 trials (24 verbs x 5 sentence types x 2 agent/patient mappings), with each participant completing only one. Sentences were also created for seven practice trials (for which typical ratings were provided): translations of those used in the English, Indonesian and Mandarin studies described above.

Sentences were audio recorded by a native speaker of Balinese (the first author) and presented in random order, along with accompanying videos (again, the same as used in previous studies). Participants provided their ratings using a 10-point Likert scale on the Gorilla platform.

Semantic rating task

Participants rated, by completing an Excel spreadsheet, each of 49 verbs for each of 10 semantic properties (again, the same used in previous studies), using a 9-point scale:

> (a) A causes (or is responsible for) some effect/change involving B, (b) A enables or allows the change/event, (c) A is doing something to B, (d) A is responsible, (e) A makes physical contact with B, (f) B changes state or circumstances, (g) B is responsible [predicted to have a negative relationship with passivizability], (h) It would be possible for A to deliberately [VERB] B, (i) The event affects B in some way, (j) The action adversely (negatively) affects B.

These were the same properties rated (in translation) in previous studies of English (Ambridge et al., 2016; Bidgood et al., 2020), Indonesian (Aryawibawa & Ambridge, 2018), and Mandarin Chinese (Liu & Ambridge, 2021), and ultimately derive from Pinker (1989). In order to ensure that passivizability did not affect participants' semantic ratings, passives were not mentioned in the task or study description. Instead, participants were asked to consider the verbs as used in the context A VERBs B. As in the previous studies outlined above, we used Principle Components Analysis (PCC; "principal" from the R package "psych"; Revelle, 2018) to combine the individual semantic feature ratings (means taken across the 20 participants) into a single measure of passive semantics.

Following the suggestion of an anonymous reviewer, we also considered creating two predictors based on questions that primarily target (1) the agent (a, b, c, d, e, h) and (2) the patient (f, g, i, j). However, a forced two-factor PCA did not yield a statistically significant fit to the data (*chi-square* =35.16 p=0.11, n.s.), unlike the considerably better automatically-selected single-factor PCA (*chi-square* =129.2, p=1e-12). This demonstrates that all questions were effectively "asking the same thing", and that it would therefore be inappropriate to create two separate predictors, which would inevitably be very highly correlated with one another.

Finally, it is important to note that, unlike Ambridge et al. (2016), Aryawibawa & Ambridge (2018) and Liu & Ambridge (2021), we were not able to include as a control predictor the frequency of each verb in each construction, since no corpus of Balinese exists. However, we consider this to be only a minor limitation given that, in large part, the frequency of a particular verb in a particular construction is a consequence of its semantic computability with that construction: Almost by definition, speakers do not use verbs in constructions with which they are semantically incompatible.

Results

Figure 1 shows the mean ratings (on the 10-point scale) for each verb in each sentence construction, and the relationship between these ratings and the composite semantic affectedness predictor (in Standard Deviation units).

All analyses were conducted in the R environment (R Core Team, 2015). Because there remains a good deal of controversy regarding the relative merits of frequentist versus Bayesian analyses, we report both.

Frequentist mixed effects models built using the lme4 package (Bates et al., 2015) would not converge without a very simple random effects structure that included no random slopes. We therefore used the JuliaCall package (Li, 2019) to interface with the JuliaStats Mixed Models package (Bates et al., 2021). Bayesian models equivalent to the "winning" frequentist models (i.e., those with the lowest AIC value) were built using the brms package (Bürkner, 2017). Given the exploratory approach taken in the present study, we used a wide-flat prior (M=0, SD=10, with all predictors scaled and centred).

All models had fixed effects for the composite semantics

Table 2. Passive sentences used in the study. For brevity, (a) corresponding active forms are not shown and (b) only a single counterbalance condition is shown.

Balinese (passive) sentence	English translation
nak muani ento (ka-/ma-) kelid (a-/ø) teken nak luh ento	The man was avoided by the woman
nak muani ento (ka-/ma-) cegut (a-/ø) teken nak luh ento	The man was bitten by the woman
nak muani ento (ka-/ma-) kauk (a-/ø) teken nak luh ento	The man was called by the woman
nak muani ento (ka-/ma-) tingting (a-/ø) teken nak luh ento	The man was carried by the woman
nak muani ento (ka-/ma-) uber (a-/ø) teken nak luh ento	The man was chased by the woman
nak muani ento (ka-/ma-) getep (a-/ø) teken nak luh ento	The man was cut by the woman
nak muani ento (ka-/ma-) ulung (a-/ø) teken nak luh ento	The man was dropped by the woman
nak muani ento (ka-/ma-) daar (a-/ø) teken nak luh ento	The man was eaten by the woman
nak muani ento (ka-/ma-) tugtug (a-/ø) teken nak luh ento	The man was followed by the woman
nak muani ento (ka-/ma-) tulung (a-/ø) teken nak luh ento	The man was helped by the woman
nak muani ento (ka-/ma-) jagur (a-/ø) teken nak luh ento	The man was hit by the woman
nak muani ento (ka-/ma-) gisi (a-/ø) teken nak luh ento	The man was held by the woman
nak muani ento (ka-/ma-) gelut (a-/ø) teken nak luh ento	The man was hugged by the woman
nak muani ento (ka-/ma-) tanjung (a-/ø) teken nak luh ento	The man was kicked by the woman
nak muani ento (ka-/ma-) diman (a-/ø) teken nak luh ento	The man was kissed by the woman
nak muani ento (ka-/ma-) tujon (a-/ø) teken nak luh ento	The man was led by the woman
nak muani ento (ka-/ma-) tundik (a-/ø) teken nak luh ento	The man was patted by the woman
nak muani ento (ka-/ma-) kedeng (a-/ø) teken nak luh ento	The man was pulled by the woman
nak muani ento (ka-/ma-) tulud (a-/ø) teken nak luh ento	The man was pushed by the woman
nak muani ento (ka-/ma-) kocok (a-/ø) teken nak luh ento	The man was shaken by the woman
nak muani ento (ka-/ma-) teteh (a-/ø) teken nak luh ento	The man was squashed by the woman
nak muani ento (ka-/ma-) ajin (a-/ø) teken nak luh ento	The man was taught by the woman
nak muani ento (ka-/ma-) umbah (a-/ø) teken nak luh ento	The man was washed by the woman
nak muani ento (ka-/ma-) gugu (a-/ø) teken nak luh ento	The man was believed by the woman
nak muani ento (ka-/ma-) nyeh (a-/ø) teken nak luh ento	The man was feared by the woman
nak muani ento (ka-/ma-) engsap (a-/ø) teken nak luh ento	The man was forgotten by the woman
nak muani ento (ka-/ma-) dingeh (a-/ø) teken nak luh ento	The man was heard by the woman
nak muani ento (ka-/ma-) tawang (a-/ø) teken nak luh ento	The man was known by the woman
nak muani ento (ka-/ma-) demen (a-/ø) teken nak luh ento	The man was liked by the woman
nak muani ento (ka-/ma-) tingal (a-/ø) teken nak luh ento	The man was looked by at the woman
nak muani ento (ka-/ma-) tresna (a-/ø) teken nak luh ento	The man was loved by the woman
nak muani ento (ka-/ma-) kangen (a-/ø) teken nak luh ento	The man was missed by the woman
nak muani ento (ka-/ma-) inget (a-/ø) teken nak luh ento	The man was remembered by the woman
nak muani ento (ka-/ma-) tepuk (a-/ø) teken nak luh ento	The man was seen by the woman
nak muani ento (ka-/ma-) adek (a-/ø) teken nak luh ento	The man was smelt by the woman
nak muani ento (ka-/ma-) sadin (a-/ø) teken nak luh ento	The man was trusted by the woman
nak muani ento (ka-/ma-) ngerti (a-/ø) teken nak luh ento	The man was understood by the woman
nak muani ento (ka-/ma-) balin (a-/ø) teken nak luh ento	The man was watched by the woman
nak muani ento (ka-/ma-) gedeg (a-/ø) teken nak luh ento	The man was angered by the woman
nak muani ento (ka-/ma-) pedih (a-/ø) teken nak luh ento	The man was annoyed by the woman
nak muani ento (ka-/ma-) tenangin (a-/ø) teken nak luh ento	The man was calmed by the woman
nak muani ento (ka-/ma-) seneb (a-/ø) teken nak luh ento	The man was disgusted by the woman
nak muani ento (ka-/ma-) ganggu (a-/ø) teken nak luh ento	The man was distracted by the woman
nak muani ento (ka-/ma-) gugul (a-/ø) teken nak luh ento	The man was disturbed by the woman

Balinese (passive) sentence	English translation
nak muani ento (ka-/ma-) kagum (a-/ø) teken nak luh ento	The man was impressed by the woman
nak muani ento (ka-/ma-) sebet (a-/ø) teken nak luh ento	The man was saddened by the woman
nak muani ento (ka-/ma-) jerih (a-/ø) teken nak luh ento	The man was scared by the woman
nak muani ento (ka-/ma-) kesiab (a-/ø) teken nak luh ento	The man was surprised by the woman
nak muani ento (ka-/ma-) canden (a-/ø) teken nak luh ento	The man was teased by the woman

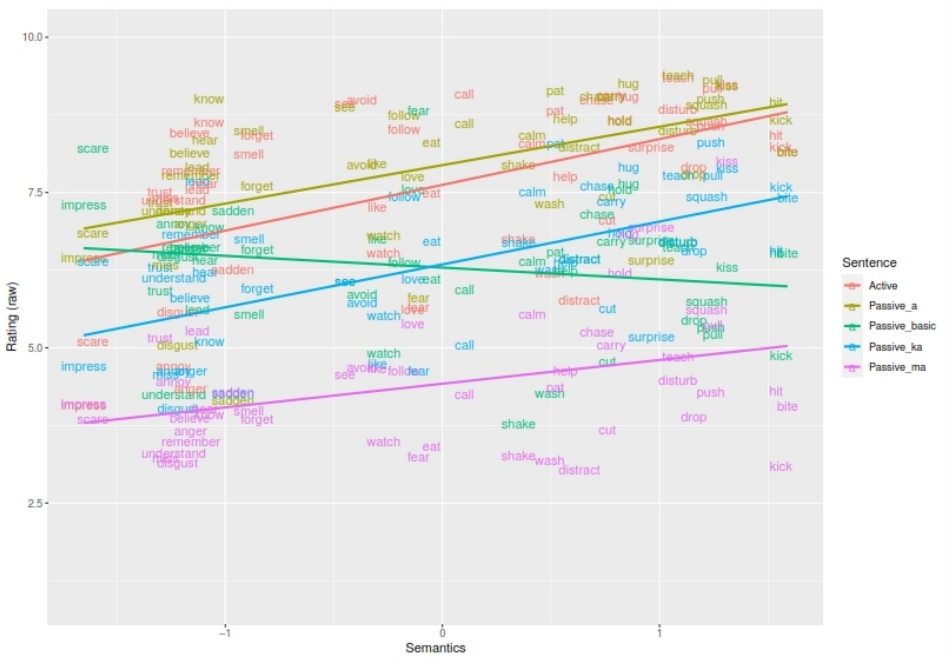

Figure 1. Mean ratings (on the 10 point scale) for each verb in each sentence construction as a function of the composite semantic affectedness predictor (in SD units). Lines show smooth conditional means (method=lm)

predictor ("Semantics"), Sentence Type ("Type": Active, Passive_a, Passive_ka, Passive_ma, Passive_basic) and either (a) a slash (/) operator or * for the interaction. That is, the first set of models include the term "Type/Semantics" which evaluates the effect of semantics at each level of Type (i.e., for each sentence type) separately. This tests the prediction set out above that "at least one of the *-a, ka-*, *ma-* and basic passive constructions will show a semantic affectedness effect". The second set of models included the familiar interaction term "Type*Semantics" which compares the effect of Semantics at each level of Type (Passive_a, Passive_ka, Passive_ma, Passive_basic) to the effect of Semantics at the default, reference level of Type (Active). This tests the prediction set out above that "we would also expect the active construction to show an affectedness effect; albeit a smaller one than observed for passives". Sentence Type was coded using treatment (dummy) coding with "Active" as the reference level.

In terms of random effects, all models had random intercepts for Verb and Participant. Starting with models with both by-verb and by-participant effects for the interaction of Semantics/Participant or Semantics*Participant (explained below) we then simplified the models as follows (shown only for the "/" models), choosing the model with the lowest AIC value (and likewise for the "*" models).

Response ~ Type/Semantics +...
(1+Type/Semantics|Verb) + (1+Type/Semantics|Participant)
(1+Type+Semantics|Verb) + (1+Type/Semantics|Participant)
(1+Type/Semantics|Verb) + (1+Type+Semantics|Participant)
(1+Type+Semantics|Verb) + (1+Type+Semantics|Participant)
(1+Semantics|Verb) + (1+Type+Semantics|Participant)
(1+Type+Semantics|Verb) + (1+Type|Participant)
(1+Semantics|Verb) + (1+Semantics|Participant)
(1+Type|Verb) + (1+Type+Semantics|Participant)
(1+Type+Semantics|Verb) + (1+Type|Participant)
(1+Type|Verb) + (1+Type|Participant)
(1+Type|Verb) + (1|Participant)
(1+Semantics|Verb) + (1|Participant)
(1|Verb) + (1+Type|Participant)
(1|Verb) + (1+Semantics|Participant)
(1|Verb) + (1+Semantics|Participant))

For both the "/" and "*" models, the second model shown

Table 3. Frequentist mixed effects model for Balinese grammatical acceptability judgment data: Effect of Semantics (affectedness) at each level of (sentence) Type ("/" model)

	Coef.	Std. Error	z	Pr(>z)
(Intercept)	7.65991	0.244239	31.36	<1e-99
Type: Passive_a	0.333311	0.157282	2.12	0.0341
Type: Passive_basic	-1.4027	0.304155	-4.61	<1e-5
Type: Passive_ka	-1.28255	0.250366	-5.21	<1e-6
Type: Passive_ma	-3.22044	0.293628	-10.97	<1e-27
Type: Active & Semantics	0.717873	0.177014	4.06	<1e-4
Type: Passive_a & Semantics	0.592678	0.192346	3.08	0.0021
Type: Passive_basic & Semantics	-0.162899	0.163316	-1.00	0.3185
Type: Passive_ka & Semantics	0.723026	0.162659	4.45	<1e-5
Type: Passive_ma & Semantics	0.409904	0.153814	2.66	0.0077

Table 4. Frequentist mixed effects models for Balinese grammatical acceptability judgment data: Interaction of Semantics (affectedness) by (sentence) Type ("*" model)

	Coef.	Std. Error	z	Pr(>z)
(Intercept)	7.65986	0.243857	31.41	<1e-99
Type: Passive_a	0.332614	0.156772	2.12	0.0339
Type: Passive_basic	-1.40307	0.30386	-4.62	<1e-5
Type: Passive_ka	-1.28274	0.249807	-5.13	<1e-6
Type: Passive_ma	-3.21997	0.292928	-10.99	<1e-27
Type: Active & Semantics	0.71725	0.176724	4.06	<1e-4
Type: Passive_a & Semantics	-0.124587	0.141606	-0.88	0.3790
Type: Passive_basic & Semantics	-0.878953	0.268729	-3.27	0.0011
Type: Passive_ka & Semantics	0.00571206	0.151104	0.04	0.9698
Type: Passive_ma & Semantics	-0.306771	0.212352	-1.44	0.1486

(in bold) had the lowest AIC value, and was therefore selected for reporting. All models can be found in Appendix 1 (frequentist) and Appendix 2 (Bayesian).

Frequentist models

Table 3 shows the frequentist model that evaluates the effect of semantic affectedness at each level of sentence type. As suggested by inspection of Figure 1, the *-a, ka-* and *ma-* passives all showed effects of semantic affectedness in the predicted direction at $p<0.01$ or better, as did the active construction. The basic passive, however, did not show any significant effect of semantics (and was not even in the predicted direction).

Table 4 shows the frequentist model that compares the effect of semantics for each passive construction to the effect of semantics for the active construction (the reference level). The only comparison that reached significance was between the active and the basic passive, which – as we have already seen – was not in the predicted direction. Thus, we do not have any evidence for the prediction set out above that the effect of semantic affectedness will be smaller for actives than for passives (nor, indeed, for the alternative possibility that it is greater).

Incidentally, the positive main effect for *a-* passives and the negative mean effect for *ka-, basic* and *ma-* passives indicates that, irrespective of verb semantics, *a-* passives were rated as significantly more acceptable than actives (probably due to the patient-focussed nature of the events), while *ka-, basic* and – in particular – *ma-* passives were rated as significantly less acceptable than actives (compare the heights of the lines in Figure 1). Presumably this latter finding is due to the fact that, as noted in the Introduction, full passives (with a *by-/teken-* phrase) favour *-a* passives, with the other types dispreferred.

Before moving on to the Bayesian analyses, we used the performance package (Lüdecke et al., 2021) to test modelling assumptions (check_model function). This latter step is particularly important, given that we fit a linear model to Likert-scale data which is technically not continuous linear interval-scale data.

Tests of the model's assumptions are shown in Figure 2. Inspection of Figure 2 reveals that all assumptions are met, with the only slight deviation regarding homogeneity of

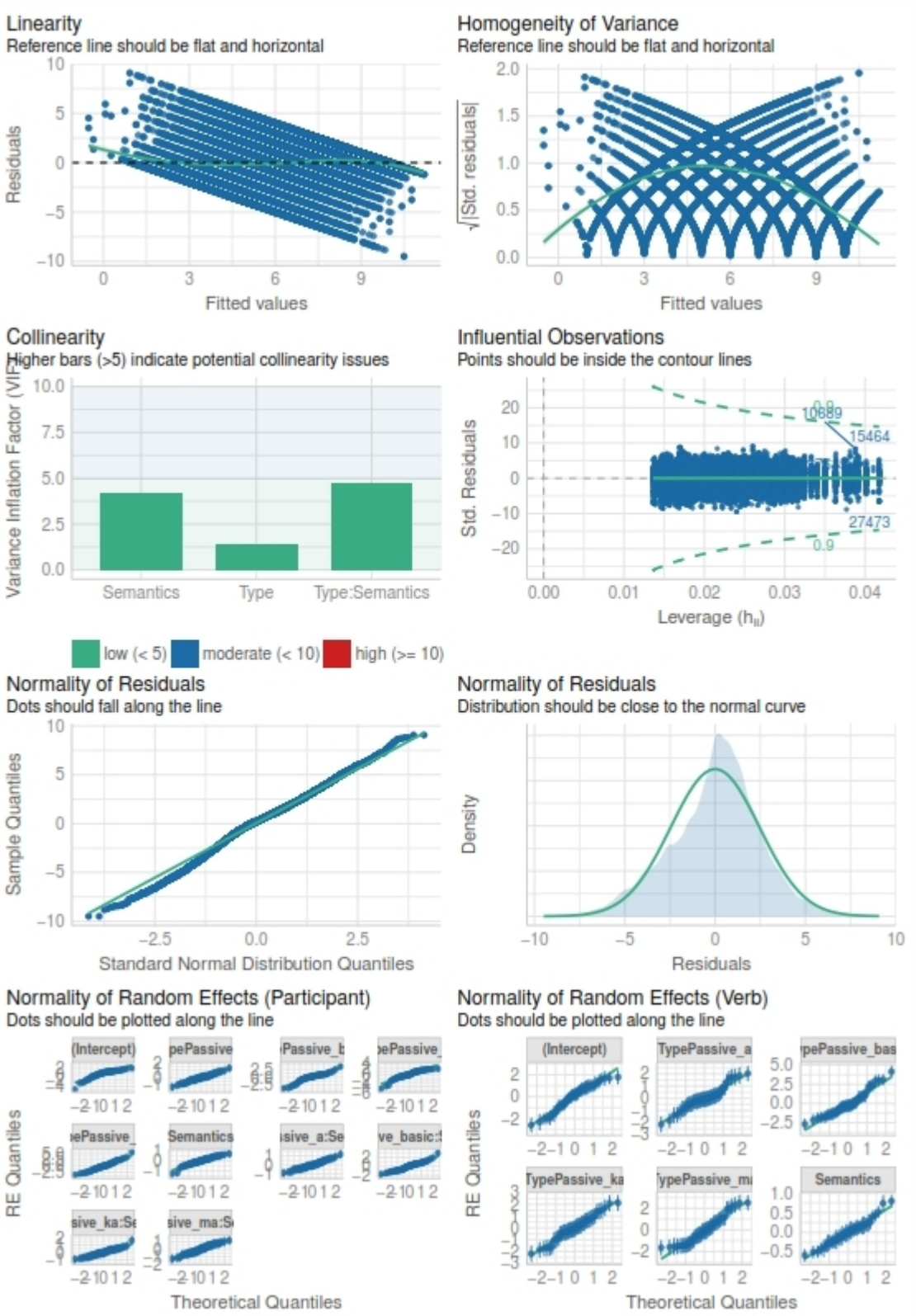

Figure 2. Tests of model assumptions.

Table 5. Bayesian mixed effects model for Balinese grammatical acceptability judgment data: Effect of Semantics (affectedness) at each level of (sentence) ype ("/" model)

Covariate	Estimate	Est. Error	1-95% CI	u-95% CI	B < > 0	Pmcmc
Intercept	7.62	0.24	7.15	8.09	1.00	0
TypePassive_a	0.32	0.16	0.00	0.64	0.97	0.03
TypePassive_basic	-1.34	0.30	-1.92	-0.75	1.00	0
TypePassive_ka	-1.26	0.26	-1.76	-0.76	1.00	0
TypePassive_ma	-3.19	0.29	-3.76	-2.61	1.00	0
TypeActive:Semantics	0.74	0.18	0.38	1.10	1.00	0
TypePassive_a:Semantics	0.62	0.17	0.28	0.95	1.00	0
TypePassive_basic:Semantics	-0.20	0.19	-0.57	0.17	0.85	0.15
TypePassive_ka:Semantics	0.71	0.17	0.36	1.08	1.00	0
TypePassive_ma:Semantics	0.39	0.18	0.04	0.74	0.98	0.02

Table 6. Bayesian mixed effects models for Balinese grammatical acceptability judgment data: Interaction of Semantics (affectedness) by (sentence) Type ("*" model)

Covariate	Estimate	Est. Error	1-95% CI	u-95% CI	B < > 0	Pmcmc
Intercept	7.62	0.24	7.15	8.09	1.00	0
TypePassive_a	0.32	0.16	0.00	0.64	0.97	0.03
TypePassive_basic	-1.34	0.29	-1.91	-0.76	1.00	0
TypePassive_ka	-1.27	0.26	-1.77	-0.76	1.00	0
TypePassive_ma	-3.19	0.29	-3.76	-2.61	1.00	0
TypeActive:Semantics	0.74	0.38	1.10	1.00	0	0
TypePassive_a:Semantics	-0.12	0.16	-0.43	0.18	0.78	0.22
TypePassive_basic:Semantics	-0.93	0.26	-1.44	-0.42	1.00	0
TypePassive_ka:Semantics	-0.03	0.17	-0.37	0.32	0.56	0.44
TypePassive_ma:Semantics	-0.35	0.20	-0.75	0.05	0.96	0.04

variance: The line is broadly-speaking horizontal, but bends down at the end, revealing that the model is most accurate for ratings at the top end of the scale.

Bayesian models

The equivalent Bayesian models are shown in Table 5 ("/" model which estimates the effect of semantics for each sentence type) and Table 6 ("*" model which compares the effect of semantics for each passive construction to the effect of semantics for the active construction). Detailed models can be found in Appendix 2.

In both cases, the estimates and standard errors are all but identical for the frequentist and Bayesian models. The question of which effects are "statistically significant" is moot from a Bayesian perspective. For purely comparative purposes, however, we used the Lazerhawk package (https://github.com/m-clark/lazerhawk) to calculate a Bayesian equivalent to *p* values (column Pmcmc), defined as the proportion of posterior samples < 0 (for positive effects) or > 0 (for negative effects). Adopting the frequentist cut-off of <0.05, the Bayesian analysis yields the same pattern of "significant" and "nonsignificant" effects as the frequentist analysis (indeed, in many cases, the Bayesian *Pmcmc* values are similar to the frequentist *p* values). The same pattern holds if we define the Bayesian equivalent to "significance" as a 95% credible interval that does not cross zero.

Summary

In summary, the fitted statistical model met the necessary modelling assumptions reasonably well, and demonstrated that, as predicted, significant effects of the semantic predictor were observed in the expected (positive) direction for *-a, ka-* and *ma-* passives, but not non-canonical (basic) passives. Somewhat unexpectedly, a significant effect of a similar magnitude was also observed for actives, indicating that this construction too is prototypically associated with the semantic property of affectedness in Balinese.

Discussion

A long-standing question in cognitive science is the nature of speakers' utterance-level syntactic representations. Under traditional "pure syntax" approaches (e.g., Chomsky, 1993) these representations contain syntactic category information, but not semantic information. Under "semantics-based" approaches (e.g., Goldberg, 1995) both form and functional-semantic information are represented. Support for pure-syntax approaches comes from previous studies of passive priming (e.g., Branigan & Pickering, 2017; Messenger et al., 2012) which found robust priming effects that did not differ as a function of verb semantics (or did so to only a very minor degree; Darmasetiyawan et al., 2022). Support for semantics-based approaches comes from previous studies that have found greater passive production for verbs with a higher degree of semantic affectedness in English (Ambridge et al., 2016; Bidgood et al., 2020), Indonesian (Aryawibawa & Ambridge, 2018), and Mandarin Chinese (Liu & Ambridge, 2021).

The aim of the present study was to test for similar effects of semantic affectedness in Balinese. In a departure from previous studies of this type, verbs were rated in four different passive constructions, as well as the canonical active construction. As predicted by the semantics-based account, semantic effects were observed for three types of passives (*ka-*, *ma-*, and *-a*), as well as the active construction, but not for the Objective Voice/Basic Verb construction (Arka, 2003; Artawa, 2013) – what we term the *Basic Passive* – which follows passive word order, but lacks morphological marking.

In addition to providing crosslinguistic support for semantics-based approaches to the passive more generally (with effects observed for English, Mandarin, Indonesian and now Balinese), the present findings shed light on two language-internal questions discussed in the linguistics literature regarding the status of the Balinese passive constructions. First, the finding that Objective Voice/Basic Verb sentences showed, if anything, a negative correlation with affectedness provides support for the view that this construction is not a bona-fide passive construction (Arka, 2003; Artawa, 2013), given that all the other passives do display such an effect.

Second, given that the scenes depicted in the animations were mostly volitional (having humans in both roles), the pattern of ratings (*-a* > *ka-* & *Basic* > *ma-*) provides support for the view (e.g., Udayana, 2013) that *-a* passives are mainly used for volitional actions, *ka-* for non-volitional actions, and *ma-* passives in contexts when the agent is deemed unimportant, and is almost always omitted (hence the sense of ungrammaticality when, as in our test sentences, it is present). Note that although we did not specifically test for this pattern statistically it is clearly present in the data, given (see Table 3) that (a) *-a* passives are rated as significantly *more* acceptable than actives (the reference category) (M=0.33, SE=0.15, p=0.03), (b) *ka-* and *Basic* passives are rated as significantly *less* acceptable than actives (M= -1.28, SE=0.25, p=<1e-6; M= - 1.40, SE=0.30, p=<1e-5) and (c) *ma-* passives are also rated as significantly less acceptable than actives, but with a considerably larger effect size (M= -3.21, SE=0.29, p=<1e-27) than for *ka-* or Basic passives.

In conclusion, setting aside these language-internal debates, the present study has provided further support for semantics-based accounts of the passive crosslinguistically and – by extension – for semantics-based accounts of syntactic knowledge more generally. Future research should seek to reconcile the apparent discrepancy between studies of the present type which typically observe semantic effects (e.g., Ambridge et al., 2016; Aryawibawa & Ambridge, 2018; Bidgood et al., 2020; Liu & Ambridge, 2021) and syntactic priming studies which typically do not (e.g., Darmasetiyawan et al., 2022; Messenger et al., 2012). Assuming both types of findings stand up to further experimental scrutiny, any successful account of the nature of speakers' syntactic representations will have to explain both semantics-free and semantics-based syntactic knowledge.

Contributions

Sena Darmasetiyawan (SD), Ben Ambridge (BA)
Contributed to conception and design: SD, BA
Contributed to acquisition of data: SD
Contributed to analysis and interpretation of data: BA
Drafted and/or revised the article: SD, BA
Approved the submitted version for publication: SD, BA

Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability statement

All data and analysis code can be downloaded from: https://osf.io/k265j/. DOI: DOI 10.17605/OSF.IO/K265J. Stimuli and materials can be accessed at: https://app.gorilla.sc/openmaterials/257204

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Supplementary Materials

Peer Review History

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Appendix 1

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Appendix 2

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