Diachronic Semantic Shift of Sequential Conjunction: 
the Causal to Conditional Path*

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Abstract This paper analyzes the semantic shift of a Japanese construction V-e-ba from causal to conditional. The conventional meaning of the V-e-ba construction is a sequential conjunction in the sense of update semantics, i.e., \(c[\varphi \text{-} \text{e-ba} \psi] = c[\varphi][\psi]\). The causal meaning in Old Japanese is obtained by an I-implicature, while the conditional meaning in Modern Japanese is obtained by Q-implicatures. The proposed diachronic development is in accordance with Deo’s (2015) Evolutionary Game Theory model.

Keywords: historical linguistics, semantic shift, conjunction, causality, conditional, pragmatics, implicatures, evolutionary game theory

1 V-e-ba

This paper analyzes the diachronic semantic shift of the Japanese V-e-ba construction. In Old Japanese (OJ), V-e-ba appears to mark a causal adjunct clause as can be seen in the use of causal connectives, because in the English translation (1a) and node in the Modern Japanese (ModJ) translation (1b).

(1) a. kurushiki koto nomi masar-e-ba, ito itau omohiwabitaru wo 
harsh things only increase-E-BA, very much depressed 

‘Because only harsh things increased, Ko’oi was very much depressed.’

(Old Japanese; Genji, 11th C)

b. tsurai koto bakari fueteiku node, Ko’oi-ga taisoo hidoku 
harsh things only increase because, Ko’oi-NOM very much 

‘Because only harsh things increased, Ko’oi was very much depressed.’

(Old Japanese; Genji, 11th C)

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Diachronic Semantic Shift of Sequential Conjunction

On the other hand, the V-\textit{e-ba} form in ModJ appears to mark a conditional adjunct (antecedent) as in (2a), while in OJ the conditional is marked with V-\textit{a-ba} form as in (2b).

\begin{enumerate}
\item a. uramu no-ga mottomona ten-mo kawairashiku bokashite hate NML-NOM reasonable point-ADD sweetly vaguely
i-e-ba, sorenitsukete otoko-no aijoo-mo masu koto deshoo say-E-BA, as.it.goes men-GEN love-ADD increase NML will ‘Even the things you definitely hate, if you just mention them sweetly, men will love you more.’ (Modern Japanese)
\item b. uramu bekaram fushi-o-mo, nikukarazu kasumenas-a-ba, hate should thing-ACC-ADD sweetly mention-A-BA, sorenitsukete ahare-mo masarinu-besi as.it.goes love-add increase-should
\end{enumerate}

(Old Japanese; Genji, 11th C)

Furthermore, in Middle Japanese (MidJ), the use of V-\textit{e-ba} as logical/symmetric conjunction has emerged as in (3).

\begin{enumerate}
\item narimono-ni obie-nu mo ar-e-ba, obieru ko mo loud.noise-DAT scared-NEG ADD exist-E-BA scared child ADD
ar-oosi.
exist-probably
‘Probably, some kids are not scared by a loud noise and some are scared.’ (Middle Japanese; Ukiyoburo, 19th C)
\end{enumerate}

The goal of this paper is to account for how the interpretation of V-\textit{e-ba} shifted from causal to conditional (via logical/symmetric conjunction). The core semantics of the V-\textit{e-ba} construction is a sequential conjunction in the sense of update semantics, i.e., \(c[\varphi\text{-e-ba } \psi] = c[\varphi][\psi]\). The causal meaning in OJ is obtained by an I-implicature (conjunction buttressing), while the conditional meaning in ModJ is obtained by Q-implicatures. The proposed diachronic development can be formalized by Deo’s (2015) Evolutionary Game Theory that underpins the grammaticalization paths from the semantic-pragmatic perspective.

2 Puzzles of the Traditional Grammar

2.1 Settled Conditional to Hypothetical Conditional

In the traditional Japanese grammar (e.g., Sakakura 1958), two verbal morphemes adjacent to -\textit{ba} in OJ are said to mark whether the event expressed by the verb is
settled or not: -a and -e are called mizen ‘unsettled/irrealis’ and izen ‘settled/realis’, respectively. Together with the assumption that -ba unambiguously marks conditional, the V-a-ba and V-e-ba constructions are named katee jooken ‘hypothetical conditional’ and kakutee jooken ‘settled conditional’, respectively.

Following Sakakura’s terminology, Kobayashi (1996) explains the semantic shift of V-e-ba from causal to conditional as follows. First, $\phi$-e-ba $\psi$ in OJ expresses conditional dependency between two settled propositions, which gives rise to a causal interpretation, $\phi$ causes $\psi$. This causal dependency between $\phi$ and $\psi$ had been generalized over time and the V-e-ba construction has gained a hypothetical interpretation, if $\phi$, then $\psi$. At the same time, the realis/settledness feature of V-e is lost. Thus, in the traditional grammar, the -e morpheme in ModJ is now called katee kee ‘hypothetical form’. This historical change of the terminology is summarized in Table 1.

### Table 1: Terminology Change of Traditional Grammar

<table>
<thead>
<tr>
<th>Old Japanese</th>
<th>Modern Japanese</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-a</td>
<td>mizen ‘unsettled/irrealis’</td>
</tr>
<tr>
<td>V-e</td>
<td>izen ‘settled/realis’</td>
</tr>
<tr>
<td>V-a-ba</td>
<td>katee jooken ‘hypothetical conditional’</td>
</tr>
<tr>
<td>V-e-ba</td>
<td>kakutee jooken</td>
</tr>
<tr>
<td></td>
<td>‘settled conditional’</td>
</tr>
</tbody>
</table>

2.2 Puzzles

The traditional account sketched above is puzzling in at least three respects. First, it is unclear what motivates the generalization of the causal e-ba into the conditional. In particular, OJ already had the a-ba conditional which seems to express the genuine conditional. Second, it is mysterious why the settledness/realis feature of -e is lost.

Finally, the traditional explanation is puzzling in view of Traugott & Dasher’s (2002) generalizations of language change: “Meanings tend to become increasingly based in the speaker’s subjective belief state/attitude toward the proposition” (p. 95), and “meanings become increasingly more pragmatic and procedural” (p. 40) in that they express meta-linguistic relations between contentful meanings. To illustrate, let us take the English connective because and see how its interpretation has become more subjective and procedural over time. In (4), three types of causation are demonstrated. The causation expressed in (4a) is more or less an objective one between two eventualities, while the one in (4b) involves the speaker’s subjective/epistemic
reasoning on why she thinks John loved her. Furthermore, the because-clause in (4c) indicates the motivation for why the speaker is performing such a speech act rather than the propositional content of the main clause.

(4) a. John came back because he loved her. (content)
   b. John loved her, because he came back. (epistemic)
   c. What are you doing tonight, because there’s a good movie on. (speech act)

(Sweetser 1990: 77)

Going back to the causal to conditional shift of the V-e-ba construction, a causal statement like (1a) is more subjective and procedural in that it involves the speaker’s judgment that there is a causal dependency between two facts, while a conditional statement like (2a) is less subjective and less procedural in that it merely expresses quantification over event predicates. Thus, the claim that V-e-ba shifted from causative to conditional does not fit the general trend of semantic change.

3 Proposal

I propose that the semantics of the V-e-ba construction is a sequential conjunction based on Fukuda’s (2006) observation. In Section 3.1, I first review Fukuda’s (2006) analysis with some corpus data which support his claim. Section 3.2 presents my own analysis.

3.1 Fukuda (2006): e-ba as conjunction

Fukuda (2006) presents convincing evidence against the traditional view and claims that the ba particle is ambiguous: The particle ba in V-e-ba is a conditional maker while ba in V-e-ba is not a marker of conditional but a marker of conjunction. Furthermore, the verbal morphemes -a and -e are not markers of (un)settledness/(ir)realis but markers of syntactic positions. I translate Fukuda’s claim in generative terms as follows: -a is a marker of infinite ([−FINITE]) Aspect Phrase (AspP) as depicted in (5), while -e is a marker of finite ([+FINITE]) CP as in (6).

(5)

```
AspP
   VP
   Asp
   [−FINITE]
   -a
```
Fukuda (2006) motivates his claim with the following observational fact. As already indicated in the tree structures above, -a cannot embed a modal while -e can. That is, OJ modals of probability, m, ram, kem cannot be followed by -a (i.e., "m-a, "ram-a, "kem-a), while m-e, ram-e, kem-e forms are available. An example of m-e is given in (7).

(7) monohakanaki mi-ni-ha suginitaru yosono oboe-ha humble myself-DAT-TOP too.much others rumor-TOP ara-m-e exist-might-E although

‘Although there might be some rumors that it is too much for a humble person like me.’ (Old Japanese; Genji, 11th C)

Furthermore, this distributional pattern can be attested in the Corpus of Historical Japanese (CHJ). There are zero occurrences of m-a, ram-a, and kem-a while m-e, ram-e, kem-e forms frequently occur.

Therefore, semantically speaking, clauses headed by -a denote event predicates or unsaturated propositions, while clauses headed by -e denote saturated propositions. Thus, (2b) with V-a-ba_1 is a genuine conditional which expresses quantification over event predicates (Kratzer 1991), while (1b) with V-e-ba_2 is not a conditional but a conjunction of two saturated propositions.

<table>
<thead>
<tr>
<th></th>
<th>-a</th>
<th>-e</th>
</tr>
</thead>
<tbody>
<tr>
<td>m-</td>
<td>0</td>
<td>1327</td>
</tr>
<tr>
<td>ram-</td>
<td>0</td>
<td>187</td>
</tr>
<tr>
<td>kem-</td>
<td>0</td>
<td>107</td>
</tr>
</tbody>
</table>

Table 2 Co-occurrences of OJ modalities and verbal morphology in the Corpus of Historical Japanese (CHJ)
To summarize, according to Fukuda’s (2006) analysis, the clause headed by the -a morpheme is an AspP which denotes an event predicate or an unsaturated proposition, while the clause headed by the -e morpheme is a CP which denotes a saturated proposition. Furthermore, Fukuda (2006) claims that the particle ba is ambiguous between conditional and conjunction. Thus, \( \varphi\cc\psi \) is a genuine conditional while \( \varphi\cc e-ba\cc \psi \) is a conjunction of two facts.

3.2 Analysis

I propose that the default semantics of \( \varphi\cc e-ba\cc \psi \) is sequential conjunction in update semantics (Stalnaker 1968; Heim 1982):

\[
(8) \quad \text{Proposal 1}
\]
\[
c[\varphi\cc e-ba\cc \psi] = c[\varphi]\cc c[\psi].
\]

Thus, the semantic interpretation of (1a) is: ‘only harsh things increased AND she was very much depressed’. Indeed, (9) shows that OJ \( \varphi\cc e-ba\cc \psi \) expressed a sequential conjunction of events in chronological order, ‘\( \varphi \) and then \( \psi \)’, rather than a causal relation.

\[
(9) \quad \text{sore-o mir-e-ba, sansun bakari naru hito, ito utsukushiute witar-i.}
\]
\[
it-\text{ACC see-E-BA 3.inches only COP person very lovely exist-PERF}
\]
\[
\quad \text{‘He (the old man) looked at it (the bamboo shoot) and then there was}
\]
\[
\quad \text{a person, who was only three inches tall, sitting very lovely.’}
\]
\[
\text{(Old Japanese; Taketori, 9-10th C)}
\]

The causal interpretation of \( \varphi\cc e-ba\cc \psi \) in (1a) arises from pragmatic/Gricean reasoning, i.e., Levinson’s (2001) I-implicature/conjunction buttressing.

\[
(10) \quad \text{Proposal 2}
\]
\[
\text{The causal meaning of } e-ba \text{ is an I-implicature.}
\]

Levinson (2001) argues that English conjunction and can undergo pragmatic enrichment via Gricean reasoning, in particular I-principle. I-principle allows the addressee to enrich the semantic meaning of the speaker’s utterance so that it fits our stereotypical expectations:

\[
(11) \quad \text{The I-principle}
\]
\[
\text{Speaker: Do not say more than is required.}
\]
\[
\text{Addressee: What is generally said is stereotypically and specifically exemplified. (adapted from Huang 2007: 58)}
\]

For instance, the semantic interpretation of (12) is just a conjunction of two events, but the addressee will try to causally connect the two events described:
(12) John turned the key and the engine started.  
I-implicates  
John turned the key, therefore the engine started.

Similarly, in (1a), repeated here as (13), the use of conjunction e-ba I-implicates the causal interpretation as a result of the pragmatic enrichment:

(13) kurushiki koto nomi masar-e-ba, ito itau omohiwabitaru wo.
a. semantic interpretation:  
‘Only harsh things increased and she was very much depressed’.  
b. I-implicature:  
‘Only harsh things increased, therefore she was very much depressed.’

Finally, how did the conditional interpretation of e-ba in ModJ emerge? My answer is that the conditional meaning is obtained via Q-implicatures:

(14) Proposal 3  
The conditional meaning of e-ba obtains from Q-implicatures.

First, note that if c, the input context to be updated by \( \varphi \)-e-ba-\( \psi \), is a suppositional context rather than the utterance context, we obtain the ModJ-style conditional interpretation, \( \varphi \rightarrow \psi \) (Roberts 1996; Kaufmann 2000).

Furthermore, along the diachronic development, morphemes marked specifically for causal and symmetric conjunction have emerged. As for causality, kara ‘because’ and node ‘because’ emerged in 17th C and in 19th C, respectively (Kobayashi 1996). Figure 1 shows the diachronic distribution of the constructions that mark causality. As can be seen, in the Middle Era (12-17th C), causality was expressed by e-ba for more than 60% of the time while in the Modern Era, it is rarely used to denote causality.

Similarly, as for conjunction, Kobayashi (1996) reports that to ‘and’ emerged in 17th Century. Also as can be seen in Figure 2, in the Mid-Edo period (Early 18th C) around 60% of the conjunction was expressed by e-ba, while e-ba is hardly used as conjunction in the Modern Era.

These markers that emerged later are semantically stronger than the default sequential conjunction. Let us first compare node and e-ba. The causal connective node is stronger than e-ba, i.e., there is a Q-scale, \( \langle \text{node}, \ e-ba \rangle \) since \( \text{CAUSE}(\varphi, \psi) \) entails \( \varphi \rightarrow \psi \), but \( \varphi \rightarrow \psi \) does not entail \( \text{CAUSE}(\varphi, \psi) \). Therefore, \( \varphi\text{-}e-ba\text{-}\psi \) Q-implicates \( \neg \text{CAUSE}(\varphi, \psi) \). Similarly, the conjunction to is stronger than e-ba, i.e., \( \langle \text{to}, \ e-ba \rangle \), since \( \varphi \& \psi \) entails \( \varphi \rightarrow \psi \), but \( \varphi \rightarrow \psi \) doesn’t entail \( \varphi \& \psi \). Thus, \( \varphi\text{-}e-ba\text{-}\psi \) Q-implicates \( \neg (\varphi \& \psi) \).

Figure 3 visualizes how the causal and conjunction interpretations of e-ba in OJ are taken over by semantically stronger morphemes such as node and to. Until 14th
Figure 1 Constructions that mark causality (plotted based on Table 1 on page 217 in Yajima (2013))

Century when *Heike Monogatari* was written, *e-ba* was used mainly for causal or conjunction interpretations. After the causal *node* and the conjunction *to* entered the Japanese lexicon in 17th Century, the *e-ba* construction has acquired the conditional interpretation as its main use. Indeed, in the Mid-Edo Era (18th C), the causal/conjunction use of *e-ba* decreased while its conditional use reaches more than 50%.

To recapitulate, in OJ, there was only a single construction V-*e-ba* to mark all three interpretations in question: sequential conjunction, logical/symmetric conjunction and causal. The OJ hearer had to use contextual information to disambiguate the OJ speaker’s intended meaning for a successful communication.

Put another way, as summarized in (15), OJ was at the stage of zero-CAUS, where hearers had to use contextual information to disambiguate the meaning of *e-ba*. When the MidJ speakers started to use *node* ‘because’, Japanese entered the emergent-CAUS stage. In ModJ, the interpretations of *e-ba* and *node* are grammaticalized, thus
Figure 2 Constructions that mark conjunction (plotted based on Table 3 on page 113 in Yajima (2013))

ModJ is situated in the categorical-CAUS, where the speakers exclusively use e-ba for conditionals and use node for causation.

(15) causal ⇒ conditional
a. zero-CAUS: e-ba (OJ)
b. emergent-CAUS: (node), e-ba (MidJ)
c. categorical-CAUS: node, e-ba (ModJ)

Similarly, for the conjunction-to-conditional path (16), OJ was at the stage of zero-LCON (logical/symmetric conjunction). When the MidJ speakers started to use the lexicalized logical/symmetric conjunction to, it entered the emergent-LCON stage. In ModJ, the conditional interpretation of e-ba and the conjunction interpretation of node are grammaticalized, thus the ModJ speakers use these morphemes categorically.
Diachronic Semantic Shift of Sequential Conjunction

Figure 3 Interpretations of V-e-ba (plotted based on Tables 1&2 on pages 64&66 in Yajima (2013))

(16) conjunction ⇒ conditional
   a. zero-LCON: e-ba  
   b. emergent-LCON: (to), e-ba  
   c. categorical-LCON: to, e-ba,  
   d. generalized-LCON: to

Furthermore, as for the conjunction/conditional dichotomy, ModJ seems to be entering the generalized-LCON stage since φ-to-ψ has an interpretation similar to so-called “conditional conjunctions” (Culicover 1970; Kaufmann 2018) in (Modern) English as illustrated in (17).

(17) nonbiri siteru to okureru yo. take.time PROG and late PRT
    ‘You take time and you’ll be late.’
    ≈ ‘If you take (too much) time, you’ll be late.’ (Modern Japanese)
In short, both causal-to-conditional and conjunction-to-conditional paths follow the transition procedure in (18). At the end of the zero-CAUS and zero-LCON stages, some morphemes are recruited to specifically denote the stronger interpretations (Recruitment). Then, each morpheme is categorized to denote each interpretation (Categorization). Finally, at least as for the conjunction-to-conditional path, the newly recruited morpheme is partly generalized to have the conditional interpretation (Generalization).

(18) a. Recruitment
    b. Categorization
    c. Generalization (conjunction to → conditional to)

The next section models these grammaticalization transitions of the semantics of e-ba.

4 EGT Modelling

The diachronic trajectory sketched above naturally fits into the framework of Evolutionary Game Theory (van Rooij 2004; Deo 2015). In particular, Deo’s (2015) analysis of the diachronic progressive-to-imperfective path is straightforwardly carried over to the current analyses of the causal-to-conditional and conjunction-to-conditional paths. In the following, I mainly discuss the causal-to-conditional path for illustration. Also for reasons of space, the exposition of the model in the current paper is quite sketchy. Interested readers are referred to Deo (2015) and Yanovich (2015).²

4.1 The E-ba Game

We have two states/meanings, \(T = \{\text{caus(al)}, \text{cond(itional)}\}\) and two signals/messages/linguistic forms, \(M = \{\text{node, e-ba}\}\). A speaker strategy \(S\) is a function from states to forms while a hearer strategy \(H\) is a function from forms to states. The \(\delta\) function in (19) calculates the success of communication (Jäger 2007). The communication is successful when the hearer interprets \(t\) from \(S(t)\), the form chosen by the speaker.

(19) \[\delta_t(S, H) = \begin{cases} 1, & \text{if } H(S(t)) = t \\ 0, & \text{otherwise} \end{cases}\] (Deo 2015: 29)

We also factor in formal economy. Deo (2015) assumes that it is costly to have multiple signals for the same concept, which lessens the utility of a speaker’s

² I would like to thank Ashwini Deo (p.c.) for introducing Yanovich’s (2015) work to me.
strategy. This assumption is implemented in (20). The parameter $k$ determines whether the speaker regards the success of communication with multiple forms or the cost of signal as more important (Jäger 2007). The function $n$ yields the number of expressions minus one.

(20) Speaker’s Utility: $U_s(t, S, H) = \delta_t(S, H) - k \times n(S)$ \hspace{1cm} (Deo 2015: 29)

Hearer’s utility, on the other hand, is exactly the same as the $\delta$ function:

(21) Hearer’s Utility: $U_h(t, S, H) = \delta_t(S, H)$ \hspace{1cm} (Deo 2015: 30)

Some states are more likely to be communicated than other states. Thus, the average utilities of speaker and hearer are measured by adding up the strategy utility in each state, which is loaded with probability weighting:

(22) a. Speaker’s average utility: $U_s(S, H) = \sum_t P(t) \times (\delta_t(S, H) - k \times n(S))$

b. Hearer’s average utility: $U_h(S, H) = \sum_t P(t) \times \delta_t(S, H)$ \hspace{1cm} (Deo 2015: 30)

4.2 Role of contexts

Deo (2015) adopts van Rooij’s (2004) model of signalling games enriched with contextual factors. In the current analysis, two contexts (phenomenal and structural) are considered, following Deo’s (2015) hypothesis that “[a] semantic grammaticalization path in the functional domain must be structurally underpinned by some privative contrast between a specific and a general meaning” (p. 47). As for our causal-to-conditional and conjunction-to-conditional paths, we can indeed identify such a privative contrast as summarized in (23).

(23) Two kinds of contexts:

a. phenomenal context: specific event tokens—Causal/Conjunction

b. structural context: general event types—Conditional

A causal statement like (1a) describes a phenomenal relation between specific event tokens, i.e., the event that only harsh things increased caused the event that Ko’oi got very much depressed. Similarly, a conjunction of two clauses like (9) describes a phenomenal relation between two specific events, i.e., the event that the old man looked at the bamboo shoot chronologically precedes the event that a little person was sitting inside. On the other hand, a conditional statement like (2a) describes a structural relation between general event types, most events where you mention things sweetly coincide with events where men will love you more.
In the current system, a context is a probability distribution over the state/meaning space. We have two contexts, $C = \{C_{phen}, C_{struc}\}$. In a phenomenal context, it is more likely that the agents communicate a causal meaning ($P_{phen}(caus) = 0.9$ while in a structural context, it is more likely that the agents communicate a conditional meaning ($P_{struc}(caus) = 0.1$).

Deo’s speaker and hearer strategies considered for the progressive-to-imperfective path are directly applied to the causal-to-conditional path as done in Tables 3 and 4. A speaker strategy ($S : C \times T \rightarrow M$) is now a mapping from pairs of a state and a context to forms $\{\text{node, e-ba}\}$.

$S_{cd}$ is a “context dependent” strategy where the speaker employs the e-ba form invariably. $S_{pcd}$ is a “partially context dependent” strategy where the speaker uses node to convey the caus state only in $C_{struc}$, where the cond state is more probable (i.e., $S_{pcd}(C_{struc}, \text{caus}) = \text{node}$). $S_{em}$ is an “explicit marking” strategy, where the speaker employs node to mean caus and e-ba to mean cond independently of contexts. $S_{cd'}$ is the same as $S_{cd}$ except that the speaker invariably uses node instead of e-ba.

On the other hand, a hearer strategy is now a mapping from pairs of a form and a context to states, $H : C \times M \rightarrow T$.

When the hearer employs $H_{cd}$, the hearer ignores the linguistic form uttered by the speaker and determines the meaning solely from the context. When $H_{pcd}$ is employed, the hearer interprets caus only when the speaker utters node in $C_{struc}$ (i.e., $H_{pcd}(C_{struc}, \text{node}) = \text{caus}$). When $H_{em}$ is employed, the hearer ignores the context and directly interprets node as caus and e-ba as cond. Unlike the speaker strategy, $H_{cd'}$ is unnecessary since it is exactly the same as $H_{cd}$.

After taking contexts into consideration, the average utilities of speaker and hearer are revised as follows:

\begin{align*}
\text{a. } U_s(S, H) &= \sum_c P(c) \times \sum_t P_e(t) \times (\delta_t(S, H) - k \times n(S)) \\
\text{b. } U_h(S, H) &= \sum_c P(c) \times \sum_t P_e(t) \times \delta_t(S, H) \quad \text{(Deo 2015: 32)}
\end{align*}
Diachronic Semantic Shift of Sequential Conjunction

<table>
<thead>
<tr>
<th></th>
<th>$C_{\text{phen}}$</th>
<th>$C_{\text{struc}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{\text{cd}}$</td>
<td>caus</td>
<td>e-ba</td>
</tr>
<tr>
<td>$H_{\text{pcd}}$</td>
<td>caus</td>
<td>caus</td>
</tr>
<tr>
<td>$H_{\text{em}}$</td>
<td>caus</td>
<td>cond</td>
</tr>
<tr>
<td>$H_{\text{cd}'}$</td>
<td>caus</td>
<td>caus</td>
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</table>

**Table 4** Hearer Strategies

<table>
<thead>
<tr>
<th>Strategies</th>
<th>$H_{\text{cd}}$</th>
<th>$H_{\text{pcd}}$</th>
<th>$H_{\text{em}}$</th>
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<td>$S_{\text{cd}}$</td>
<td>0.9</td>
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<tr>
<td>$S_{\text{pcd}}$</td>
<td>$0.9 - k$</td>
<td>$0.95 - k$</td>
<td>$0.55 - k$</td>
</tr>
<tr>
<td>$S_{\text{em}}$</td>
<td>$0.9 - k$</td>
<td>$0.95 - k$</td>
<td>$1 - k$</td>
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<tr>
<td>$S_{\text{cd}'}$</td>
<td>0.9</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**Table 5** Average utilities (taken from Deo 2015: 32)

Suppose now that $P(C_{\text{phen}}) = 0.5$ and $P(C_{\text{struc}}) = 0.5$ with the context values specified above. Table 5 summarizes the result of the calculation of the speaker’s average utilities. The hearer’s average utilities can be obtained by removing the parameter $k$.

When we communicate, we sometime play the role of speaker and sometime play the role of hearer. To make our model similar to the actual situation, we need to make the game symmetrized. A strategy is now defined as a pair, $\langle S, H \rangle$. The expected utility of one strategy with respect to another one is computed as in (25). Table 6 shows the result of the calculation of (25).

\[
(25) \quad \text{EU}(\langle S, H \rangle, \langle S', H' \rangle) = \frac{1}{2} \times (U_s(S, H') + U_h(S', H)) \quad \text{(Deo 2015: 33)}
\]

4.3 Replication and Mutation

To model the grammaticalization transitions summarized in (18), we now consider replication and mutation.

Suppose that $x_A$ is Strategy A’s frequency (probability). The likelihood that one strategy is replicated by another individual is determined by the average payoff (fitness) of the strategy given in (26).

\[
(26) \quad \begin{align*}
\text{a. } f_A &= ax_A + bx_B \\
\text{b. } f_B &= cx_A + dx_B 
\end{align*} \quad \text{(Deo 2015: 36)}
\]
Hara

Strategies  \( S_{cd}, H_{cd} \)  \( S_{pcd}, H_{pcd} \)  \( S_{em}, H_{em} \)  \( S_{cd'}, H_{cd} \)
\( S_{cd}, H_{cd} \)  0.9  0.9  0.7  0.9
\( S_{pcd}, H_{pcd} \)  0.9 - \frac{1}{2}k  0.95 - \frac{1}{2}k  0.75 - \frac{1}{2}k  0.7 - \frac{1}{2}k
\( S_{em}, H_{em} \)  0.7 - \frac{1}{2}k  0.75 - \frac{1}{2}k  1 - \frac{1}{2}k  0.7 - \frac{1}{2}k
\( S_{cd'}, H_{cd} \)  0.9  0.7  0.7  0.9

Table 6  Expected payoffs for paired strategies (taken from Deo 2015: 34)

Given the average payoff (fitness) of a strategy relative to the fitness of the population, the probability of replication of Strategy A after one time step (\( x_A' \)) is computed as in (27). \( \phi \) is the average fitness of the population before the time step, \( \phi = x_A f_A + x_B f_B \).

\[
(27) \quad \begin{align*}
    a. \quad x_A' &= x_A \times \frac{f_A}{\phi} \\
    b. \quad x_B' &= x_B \times \frac{f_B}{\phi}
\end{align*}
\]

(Deo 2015: 36)

Besides replication, Deo (2015) introduces mutation into the model. The motivation for introducing mutation from one strategy to another is to characterize the case that offsprings might learn a strategy different from the strategy of their parents. This paper directly adopts Deo’s (2015) discrete-time version of the “replicator-mutator” equation in (28). The frequency of strategy \( i \) after a time-step (\( x_i' \)) is determined on the basis of the probability that strategy \( j \) mutates into strategy \( i \) (\( Q_{ji} \)), the frequency of strategy \( j \) (\( x_j \)), the average payoff of strategy \( j \) (\( f_j \)) and the average fitness of the population (\( \phi \)).

\[
(28) \quad x_i' = \sum_{j=1}^{n} Q_{ji} \frac{x_j f_j}{\phi}
\]

(Deo 2015: 37)

4.4 Modeling the transitions

Finally, we are ready to model the grammaticalization transitions presented in (18). Let us take the replicator-mutator equation (28) and the mutation probabilities given in Table 7, and apply it to the causal-to-conditional and conjunction-to-conditional paths. The parameter \( k \) is set to be 0.01.

Recruitment Transition  In the zero-CAUS stage, \( S_{cd}, H_{cd} \) is most common and easy to learn, although some learners may move to \( S_{pcd}, H_{pcd} \) to avoid ambiguity and miscommunication. According to Table 7, the mutation probability from
Diachronic Semantic Shift of Sequential Conjunction

\[
Q = \begin{pmatrix}
\langle S_{cd}, H_{cd} \rangle & \langle S_{pcd}, H_{pcd} \rangle & \langle S_{em}, H_{em} \rangle & \langle S_{cd'}, H_{cd} \rangle \\
0.94 & 0.06 & 0 & 0 \\
0.02 & 0.91 & 0.07 & 0 \\
0 & 0 & 0.97 & 0.03 \\
0 & 0 & 0 & 1 
\end{pmatrix}
\]

Table 7  Mutation Probability given by Deo (2015: 41)

---

Figure 4  Dynamic behaviors of the four strategies based on \(Q\) (replica of Figure 3 in Deo (2015: 43); R codes provided by Yanovich (2015))

\(\langle S_{cd}, H_{cd} \rangle\) to \(\langle S_{pcd}, H_{pcd} \rangle\) is 0.06, i.e., \(Q_{cd, pcd} = 0.06\). The simulation based on the replicator-mutator equation (28) and the mutation probability matrix \(Q\) in Table 7 is given in Figure 4. As can be seen, \(\langle S_{pcd}, H_{pcd} \rangle\) wins over \(\langle S_{cd}, H_{cd} \rangle\) after about 20 iterations.

Categorization Transition  \(\langle S_{pcd}, H_{pcd} \rangle\) prevalent in emergent-\textsc{caus} is a demanding strategy since the speaker needs to be attentive to the context, thus offsprings tend to go for \(\langle S_{em}, H_{em} \rangle\) with the probability \(Q_{pcd, em} = 0.07\) since the parent strategy contains node, an indication toward the grammaticalization of \textsc{caus}. \(\langle S_{em}, H_{em} \rangle\) common in categorical-\textsc{caus} is a reliable strategy as can be seen in the simulation (Figure 4).

Generalization Transition  Finally, to understand the generalization of the conjunction \textit{to} to conditional \textit{to} as seen in (17), let us see how Deo (2015) models the
transition from $\langle S_{em}, H_{em} \rangle$ to $\langle S_{cd'}, H_{cd} \rangle$. Basically, the mutation probability from $\langle S_{em}, H_{em} \rangle$ to $\langle S_{cd'}, H_{cd} \rangle$, i.e., $Q_{em, cd'}$, is manipulated. The motivation behind this manipulation is the following: The increase in the frequency of *to* in the offspring input may lead to an increase of the chance in mis-learning a different strategy. Together with the assumption that learners prefer a simple grammar with a single form over another grammar with multiple forms, it is possible that as more agents employ the $\langle S_{em}, H_{em} \rangle$ strategy, there is an increase in the probability of the mutation into the $\langle S_{cd'}, H_{cd} \rangle$ strategy.

To see how this manipulation results in the desired transition, let us see how Deo (2015) manipulates $Q_{em, cd'}$ with concrete numbers. When the frequency of $\langle S_{em}, H_{em} \rangle$ ($x_{\langle S_{em}, H_{em} \rangle}$) hits 0.5, $Q_{em, cd'}$ rises from 0.03 to 0.04. When $x_{\langle S_{em}, H_{em} \rangle}$ arrives at 0.65, $Q_{em, cd'}$ further rises to 0.05. The simulation with this manipulation is depicted in Figure 5.

5 Conclusion

5.1 Summary

This paper analyzed the diachronic semantic shift of the V-*$e$-*ba construction in Japanese. I propose that the conventional meaning or semantic denotation of the construction is a sequential conjunction, i.e., $c[\phi][\psi]$, which can derive all the interpretations, i.e., causal, logical/symmetric conjunction and conditional, found throughout the history of Japanese. In particular, the causal interpretation in OJ is
obtained as an I-implicature, while the conditional interpretation in ModJ is obtained via Q-implicatures.

Furthermore, the grammaticalization transitions involved in the diachronic semantic shift of the V-e-ba construction, i.e., recruitment, categorization and generalization, are modeled within the framework of Deo’s (2015) Evolutionary Game Theory.

5.2 Remaining questions

There are a lot of remaining questions in the analysis presented in the paper. First of all, what happened to the a-ba conditional? Why did it disappear? Some other conditional constructions in Japanese are reminiscent of the a-ba conditional. For instance, conditional markers tara and nara appear to be derived from tar-a-ba (PERFECT-A-BA) and nar-a-ba (COPULA-A-BA) by dropping the final ba, respectively. However, this line of analysis is not uncontroversial. Matsushita (1928) provides a quite convincing argument that tara and nara are derived from tarya and narya by dropping the palatalization, which in turn are contracted forms of tar-e-ba and nar-e-ba.

Secondly, these other forms of conditionals available in Japanese should certainly interact with the diachronic development of e-ba.

Finally, what is the particle ba in e-ba and a-ba? Fukuda (2006) claims that it is ambiguous between conjunction and conditional. However, there is also a convincing analysis by Ohno (1982), who argues that the particle ba is etymologically related to the topic marker wa, which used to be pronounced as [p] in OJ. According to Ohno (1982), V-a-ba is derived from V-a-m-pa (V-A-MODAL-TOPIC), where [p] phonologically changed into [b] as a result of sequential voicing.

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Diachronic Semantic Shift of Sequential Conjunction

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