THE EVOLUTION *of* LANGUAGE

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Editors

Erica A Cartmill
University of California, Los Angeles, USA

Seán Roberts
Max Planck Institute for Psycholinguistics, Netherlands

Heidi Lyn
The University of Southern Mississippi, USA

Hannah Cornish
University of Stirling, UK

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EVOLUTION OF TENSE AND ASPECT

MIEKO OGURA
Linguistics Laboratory, Tsurumi University
Yokohama, 230-8501, Japan

TAKUMI INAKAZU
Hitachi Medical Co., Tokyo, 102-0021, Japan

WILLIAM S.-Y. WANG
Joint Research Centre for Language and Human Complexity,
Chinese University of Hong Kong, Hong Kong, China

One cognitive domain that may have influenced, and perhaps even shaped, the evolution of language is mental time travel - the ability to mentally relive events in the past (episodic memory) or imagine events in the future. Language structure has evolved to express different points in time, including past, present and future, and to make other temporal distinctions, such as action completed versus action ongoing. We examine the activation of Broca's and Wernicke's area in the evolution of tense and aspect of English using near-infrared spectroscopy. We demonstrate that the activation of the core brain system used in remembering the past and imagining the future induced the evolution of tense and aspect, which do not present themselves as separate categories and are interwoven in grammatical systems in that one and the same grammatical form may combine temporal and aspectual elements. After categorization of the periphrastic constructions of progressive and perfective, and auxiliaries to denote future tense, aspect is specialized to the left hemisphere, and the distinction of the forms between present, past and future tense caused less activation of the core networks of the brain. Here we can see the interaction between brain and language.

1. Historical Background

One cognitive domain that may have influenced, and perhaps even shaped, the evolution of language is mental time travel - the ability to mentally relive events in the past (episodic memory) or imagine events in the future. Language structure has evolved to express different points in time, including past, present and future, and to make other temporal distinctions, such as action completed versus action ongoing. Comrie (1985:6) defines tense as grammaticalization of location in time, and aspect as grammaticalization of expression of internal temporal constituency (of events, processes etc.). Thus defined, the two categories are conceptually close in that both deal with time. They may also be interwoven in grammatical systems in that one and the same grammatical form may combine temporal and aspectual elements in its semantics. In this study, taking the evolution of English tense and aspect as one example, we investigate the neural bases of the evolution of tense and aspect.

In Old English (OE) there were two morphological tense markers: non-past and past. Non-past tense primarily refers to the present. It also indicates that an action is going on as shown in (1). Here it covers the function of the progressive in Present-Day English (PDE). It can also express the future as shown in (2). The past tense is primarily used to refer to past time. It is also used where we might expect the perfect, or past of past (pluperfect) in PDE as shown in (3). We find that tense and aspect were interwoven in grammatical systems and the same grammatical form combined temporal and aspectual elements from Proto-Indo-European (PIE) through OE. This structure evolved to meet the need to express time traveling thought in the first place, and constrained the discourse structure from PIE through OE.

(1) What do you read, my Lord? (Shakespeare, *Hamlet* II.ii)
"What are you reading, my Lord?"

(2) … & ic arise of deaðe on þam þriddan dæge
… and I will-arise from death on that third day (*ÆCHom* I, 12 184.24)
"… and I will arise from death on the third day."

(3) Fæder min, se tima com
Father mine, that time came (*ÆCHom* II, 25 206.6)
"Father, the time has come."

To indicate that an action is ongoing, the BE-verbs (*beon, wesan* and sometimes *weorþan*) began to be used with V-*ende* construction in OE. To indicate the perfect and pluperfect, *habban* 'have' or BE-verbs began to be used with V-past participle in OE. *Willan* 'will' and *sculan* 'shall' were grammaticalized as auxiliaries to denote future time. We assume that these progressive, perfect, pluperfect and future constructions arose out of speakers' desire to be more specific than was possible with the older non-past and past tense forms in the transitional period from the syntactic organization of the clause interwoven with discourse organization in OE to the more strictly syntactic organization of the clause after ME. The constraint of the brain on the discourse structure in tense and aspect from PIE through OE (language is shaped by brain) is specified by the rigid syntactic structure after ME (brain is shaped by language). (For details on the evolution of grammatical forms, see Ogura forthcoming, Ch. 4).

2. Mental Time Travel

In the 1985, D. H. Ingvar published a paper "Memory for the future", and at approximately the same time, E. Tulving argued that episodic memory, which has traditionally been defined as a memory system that supports remembering personal experiences, allows individuals to engage in "mental time travel" into both the past and the future. Recent studies explore this phenomenon by having people recall specific episodes from past experiences or imagine episodes that might happen in the future. One way to do this starts with asking each experimental subject to compile a list of past episodes, in each case specifying a person, an object and a location. With such a list compiled, a researcher places the subject in an fMRI scanner and provides a location, person and object to prompt the subject to silently recall the corresponding episode. This is the memory phase of the study, involving mental travel back in time. To measure activity when people imagine future episodes, the subject receives prompts from the listed past episodes. Then, the researcher asks the subject to silently imagine a future episode. This task represents mental travel forward in time (Schacter et. al. 2007, Corballis 2012).

The brain activity elicited by the recovery of past episodes resembles that elicited by imagined future ones. Both involve activity in the highly specific core brain system, including the prefrontal, parietal, and medial temporal lobe regions, as well as posterior regions (including the precuneus and the retrosplenial cortex) that are consistently observed as components of brain networks that are important for memory retrieval. They are within the default network, i.e., brain regions active during the supposedly resting state, which includes regions in the prefrontal, temporal and parietal of the brain. Default mode network is measured at rest with no specific demands for focused attention. In contrast, memory and imagination performance are measured in attention-focused tasks (Schacter et al. 2007, Corballis 2012, Østby et al. 2012).

3. Interaction between Brain and Language

Because the default-mode network overlaps substantially with the core networks implied in remembering and imagination, there is an intriguing possibility that default-network connectivity is related to performance in separate attention-focused recall and imagination tasks, and further, the evolution of tense and aspect. The two classic language areas in the brain – Broca's area in the prefrontal cortex and Wernicke's area in a region overlapping the parietal and temporal lobes, as well as the connections between these two areas – lie within the core networks and the default network. In the present study we examine the activation of these two areas in the evolution of tense and aspect of English using near-infrared spectroscopy (NIRS). To assume the activation of the brain before

OE and after ME, we investigate Present-day Japanese, which shows a similar system of tense and aspect to OE, and Present-day English respectively.

In the current paradigm, we formed the English sentences: I always *read a book* (present); I *read a book* yesterday (past); I've just *read a book* (perfective); I'll *read a book* tomorrow (future); I'm *reading a book* now (progressive), and changed the italicized verb phrase into *write a letter, eat an apple, sing a song* and *play the piano*. The 25 sentences were classified into 5 groups, each of which includes one randomly chosen present, past, perfective, progressive, future sentence. In the same way we made another 5 groups, each of which includes one randomly chosen present, past, perfect, progressive and future sentence formed by changing the subject to *he* and the verb phrase into *tell a lie, break a glass plate, ask a question, drive a car* and *watch a baseball game*. A total of 50 English sentences classified into 10 groups were presented auditorily to the 6 native English speakers. All the sentences were within 5s in length. The interval between the sentences was 19s to allow the hemodynamic response to return to the baseline before initiating the following trial.

We also formed the 5 groups of Japanese sentences which correspond to the first 5 groups of English sentences: Watashi wa [I] itsumo [always] *hon wo* [book] *yomu* [read (present)] (present); Watashi wa kinou [yesterday] *hon wo yonda* [read (past)] (past); Watashi wa ima [now] *hon wo yonda* [have read] (perfective); Watashi wa asu [tomorrow] *hon wo yomu* [will read] (future); Watashi wa ima *hon wo yomu* [am reading] (progressive). In Present-day Japanese there is only one past tense suffix *ta*, which is also used in an expression of the perfective sense. Present tense form is also used in an expression of the future or progressive sense. The tense and aspect system in Present-day Japanese is similar to that in OE. We also formed another 5 groups corresponding to the second 5 groups of English sentences by changing the subject: *watashi* to *kare* [he] and the verb phrase into *uso wo* [lie] *tsuku* [tell]; *itagarasu wo* [glass plate] *waru* [break]; *shitsumon wo* [question] *suru* [ask]; *kuruma wo* [car] *untensuru* [drive]; *yakyu no shiai wo* [baseball game] *miru* [watch]. A total of 50 Japanese sentences classified into 10 groups were presented auditorily to the 6 native Japanese speakers.

The subjects were instructed to comprehend the sentences silently. The changes in hemoglobin (Hb) concentrations and their oxygeneration levels in the Broca's, Wernicke's and surrounding areas in the frontal, temporal and parietal lobes in the left hemisphere and the right homologous areas were recorded using NIRS systems (ETG-7000; Hitachi, Tokyo, Japan). 3 lines of 5 probes were fitted on the relevant areas in the left hemisphere and the right homologous areas. There were 22 channels in the optical path of the brain between the nearest pairs of emission and detection probes in each hemisphere.

Figure 1 shows the average value of the oxy-Hb changes of the 6 Japanese and 6 English subjects in Broca's, Wernicke's and surrounding areas at the 22 channels in the left hemisphere, and the homologous areas in the right

hemisphere for the past in solid lines, and for the future in broken lines in the range of ±0.05mM*mm. The average of the values during 5s before the present stimulus and before the next stimulus was the baseline for the oxy-Hb changes. The two vertical lines at each of the 22 channels show the period of 5s when the sentence was presented. The average of the subjects' Hb responses to the stimuli is shown during this period and the interval of 19s before the following stimulus. We find that the past and future in Japanese show similar patterns of activation both in the left and right hemispheres except the more activity for the future than the past in Broca's area. In contrast, the past and future in English show less activity than those in Japanese. More activity for the future than the past in Broca's area is not observed in English. Broca's area is marked in a solid circle and Wernicke's area in a broken circle in the left hemisphere in Japanese.

Figure 2 shows the average value of the oxy-Hb changes of the 6 Japanese and 6 English subjects in Broca's, Wernicke's and surrounding areas at the 22 channels in the left hemisphere, and the homologous areas in the right hemisphere for the past in solid lines, and for the progressive in broken lines. We mark the areas where the activation occurs in the progressive in solid circles. We also superposed the area where the activation for the perfective occurs in a dotted circle. We find that the past, future, progressive and perfective in Japanese show similar patterns of activation both in the left and right hemispheres. In contrast, the progressive and perfective in English show greater activation than the past in some regions in the left hemisphere, and less activity than the past, or almost no activity in the right hemisphere. The activation occurs in Broca's area and Wernicke's area for the progressive as indicated in solid circles, and in the area between them for the perfective as indicated in a dotted circle. The areas in activation for the progressive and perfective occur complementarily in the left hemisphere.

We may assume that the same pattern of activation in Broca's, Wernicke's and surrounding areas and the right homologous areas in the past, future, perfective and progressive in Japanese suggests that mental time travel into the past and the future, i.e., the core brain system used in remembering the past and imagining the future, induced the evolution of tense and aspect. In contrast, less activation in the past and future in both hemispheres in English than Japanese, and the activation of the progressive and the perfective in English on the left side of the brain suggest that the structure of the language shapes the brain.

In Japanese, tense and aspect do not present themselves as separate categories. They are interwoven in grammatical systems in that one and the same grammatical form may combine temporal and aspectual elements. Demands for focused attention become high in the default mode network, and great activation occurs in the core networks. In English, tense and aspect are separate categories, and further, differences between forms reflect temporal and aspectual distinctions. Aspect is specialized to the left hemisphere. Because it is

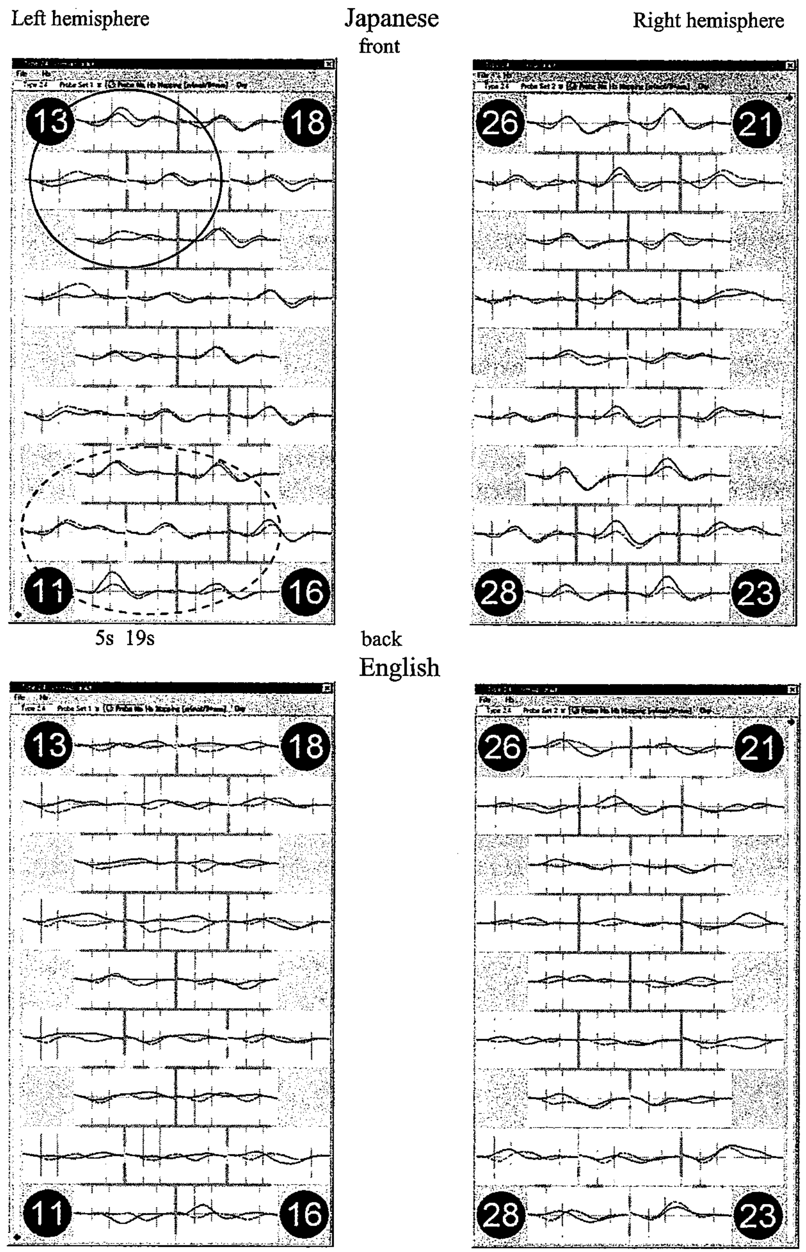

Figure 1: The oxy-Hb changes at the 22 channels in Broca's, Wernicke's and surrounding areas at the 22 channels in the left hemisphere and the homologous areas in the right hemisphere for the past in solid lines and the future in broken lines in Japanese and English

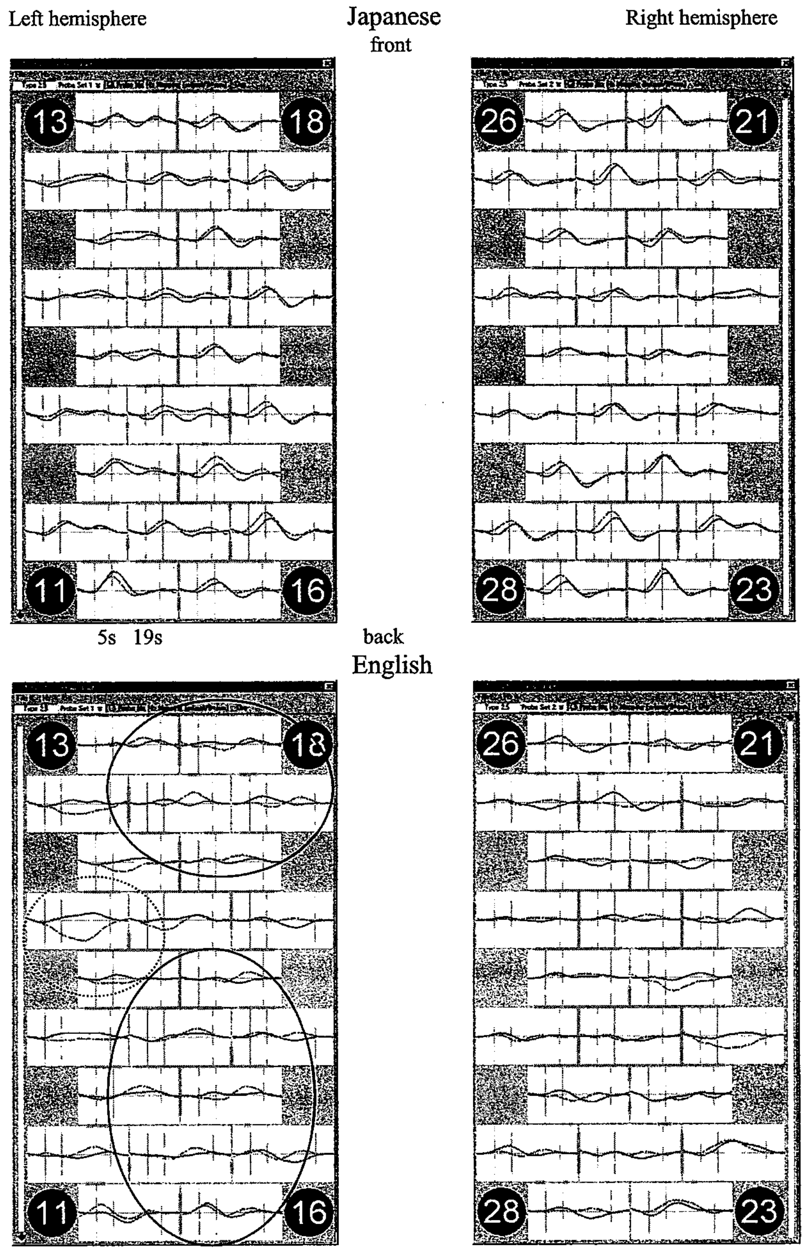

Figure 2: The oxy-Hb changes in Broca's, Wernicke's and surrounding areas at the 22 channels in the left hemisphere and the homologous areas in the right hemisphere for the past in solid lines and for the progressive in broken lines in Japanese and English

easy to distinguish tense by the different forms, there is less activation in the core networks. Furthermore, there is no greater activation in the future than the past in Broca's area.

The information on the present emerges from the immediate environment. In Japanese the activation of the present occurs in the same regions as the past and the future, but the pattern is gentler than them. In English there is mostly no activation in the core networks or just default mode network activity.

4. Conclusion

We examined the activation of Broca's and Wernicke's area in the evolution of tense and aspect of English using near-infrared spectroscopy. To assume the activation of the brain before OE and after ME, we investigated Present-day Japanese and PDE respectively, which show a similar system of tense and aspect to that before OE and after ME respectively. We demonstrated that the activation of the core brain system used in remembering the past and imagining the future induced the evolution of tense and aspect, which do not present themselves as separate categories and are interwoven in grammatical systems in that one and the same grammatical form may combine temporal and aspectual elements before OE. After categorization of the periphrastic constructions of progressive and perfective, and auxiliaries to denote future tense in ME, aspect is specialized to the left hemisphere, and the distinction of the forms between present, past and future tense caused less activation of the core networks of the brain. Here we can see the interaction between brain and language.

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OROFACIAL GESTURES IN LANGUAGE EVOLUTION: THE AUDITORY FEEDBACK HYPOTHESIS

SYLWESTER ORZECHOWSKI

Institute of Psychology,
Maria Sklodowska-Curie University, Pl. Litewski 5, Lublin 20-080, Poland

SŁAWOMIR WACEWICZ & PRZEMYSŁAW ŻYWICZYŃSKI

Center for Language Evolution Studies (CLES),
Department of English, Nicolaus Copernicus University, Bojarskiego 1
Toruń, 87-100, Poland

The so-called gestural theories of language origins have remained a central focus of language evolution research for at least a decade. Despite important differences, their varieties underscore the significance of visual, as opposed to vocal, channel of signal transmission. However, language is predominantly spoken; that is (excluding recent technologies, special ecological conditions, or high rates of congenital hearing impairment) it is the vocal modality that contemporary human societies universally use as default for linguistic communication. This immediately leads to the problem of how and why language would have transferred from being mostly-visual to mostly-vocal, which is what many influential researchers (e.g. Burling, 2005; Fitch 2010, Tallerman 2011) raise as a fundamental objection to the gestural variety. In our paper, we address a specific issue within this problem, focusing on one class of gestures - *orofacial gestures*. Employing Hockett's notion of *total auditory feedback*, we discuss the role of this feature in the emergence of speech. As detailed in section 2.1., we propose that auditory feedback may offer a partial solution to the modality transition problem.

1. The 'visual modality' theories of language origins

The modern history of the idea that language began in manual gesture rather than vocalisation dates back to the proposal of Gordon Hewes (1973), who synthesised a range of thought-provoking observations in its support. The last two decades have seen this idea supplemented with more empirically grounded arguments (see Corballis, 2002). For example, Arbib (2005) observes that non-human primates are poor at vocal imitation but share with humans the mirror neuron system that could have formed the basis for imitative signal learning. Armstrong & Wilcox (2007) point to the iconic potential of gesture as the most natural and intuitive way of expressing conceptualised contents and relations