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ABSTRACT

An ERP experiment was conducted to explore semantic and syntactic processes as well as their interplay in Chinese sentence comprehension. Participants were auditorily presented with Chinese sentences, which were either correct, semantically incorrect, syntactically incorrect, or both semantically and syntactically incorrect. The syntactic violation, which was created by eliminating the object-noun phrase from a preposition-object phrase structure, elicited an early starting anterior negativity which merged into a sustained negativity over anterior sites and a temporally limited centro-parietal negativity. The semantic violation elicited an early starting N400 effect. The combined violation in which the syntactic phrase structure violation and the semantic violation were crossed elicited an early staring sustained anterior negativity similar to the pure syntactic effect, and a centro-parietal negativity which was more negative than those of the syntactic condition and the semantic condition. No P600 was obtained neither for the syntactic nor for the combined condition. The results suggest that the syntactic processes (at about 50 ms) appear earlier than the semantic processes (at around 150 ms). They are independent from each other in the early time window (150–250 ms) but interact in a later processing phase (250–400 ms) during Chinese sentence comprehension. The broadly distributed negativity which occurred during the N400 latency range observed in meaning

munication of thoughts and feelings (Hu, 2001). Although listening to and understanding connected speech are effortless tasks in daily life, it is not well understood how the human language comprehension system processes and integrates a wide range of linguistic information within milliseconds.

With respect to syntactic and sema
tence comprehension, two main class
models have been proposed to account f
modular, syntax-first models, and inter
first models (Fodor, 1983; Frazier and Fo
the parser initially builds a syntactic st
word category information independent
formation and that thematic role assign
a second stage. If the initial syntactic stru
structure cannot be mapped onto one

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needed in the final phase. Interactive models (Bates and MacWhinney, 1987; MacDonald et al., 1994; Marslen-Wislon and Tyler, 1980; Taraban and McClelland, 1988) claim that syntactic and semantic processes already interact at an early stage. Despite the agreement that syntactic and semantic information has to be integrated within a short period of time, the two classes of psycholinguistic models differ in their views on the temporal structure of the integration processes.

caused by the mode of presentation, as presenting the sentences visually phrase-by-phrase could have affected early automatic processes as reflected by the early anterior negativity in particular. The absence could also be due to differences between typologically different languages, or to the difference in syntactic violation types used to examine the different languages.

The contrast between the absence of early ERP components in Japanese as compared to the presence of early ERP components in German and other Indo-European languages in re-

2.

2.1. Behavioral data

(1,11) = 7.01, MSE = 42.37, p < 0.05, which indicated that the syntactic and the combined conditions were more negative over lateral anterior sites. However, there was no any reliable main effect of Syntax over central or posterior sites: for left and midline central, F < 1, for right central, F(1,11) = 1.50, MSE = 44.26, p = 0.25, for right and midline posterior, F < 1, for left posterior, F(1,11) = 1.38, MSE = 32.62, p = 0.27.

In sum, for both the syntactic and the combined condition, syntactic violations elicited an early negativity which appeared first in the 50–100 ms interval and merged into an anterior sustained wave up to 1000 ms and a widely distributed negativity over central and posterior sites in the classic N400 time window (300–500 ms). But neither the pure syntactic nor the combined condition was more positive over central and posterior scalp sites after 500 ms post-onset.

2.4. Effects of the semantic violation

The ANOVA results indicated that the significant main effect of Semantics occurred as early as in the 150–200 ms interval, for midline, F(1,11) = 6.52, MSE = 13.79, p < 0.05, for lateral, F(1,11) = 7.33, MSE = 72.92, p < 0.05, and lasted until the 350–400 ms interval, for midline, F(1,11) = 5.65, MSE = 7.43, p < 0.05, for lateral, F(1,11) = 6.61, MSE = 31.98, p < 0.05 (for all intervals between 200 and 350 ms, ps < 0.01). In addition, there was a significant interaction of Semantics * Region, for midline, F(2,22) = 5.59, MSE = 0.65, p < 0.05, for lateral, F(2,22) = 5.20, MSE = 4.98, p < 0.05. However, neither the main effect of Semantics, for midline, F(1,11) = 2.16, MSE = 20.18, p = 0.17, for lateral, F(1,11) = 1.83, MSE = 137.73, p = 0.20, nor the interaction of Semantics * Region, for midline, F < 1, for lateral, F(2,22) = 2.68, MSE = 10.82, p

Dutch. Our results indicate that even though Mandarin Chinese is a language lacking affixation indicating word category, the parser could clearly processes word category information in a very short time. Later processing phases appear to be influenced by the type of syntactic structure the violation is presented in as evident in the absence/presence of the broadly distributed negativity and by the modulation of the P600 (for the latter see also Gunter et al., 2000).

3.2. Semantic processing

Our semantic violations elicited a central N400 already in a very early time window (150–400 ms) prior to the classical N400 time window (300–500 ms). Although the onset of the N400 is generally reported to be earlier in the auditory domain than in the visual domain (Holcomb et al., 1992), the earliness of the present effect deserves some discussion. The fact that our results do not exactly match the timing of the N400 reported by earlier auditory comprehension work using similar stimulus materials in English (Holcomb and Neville, 1991), in Dutch (Hagoort et al., 2003), and German (Friederici et al., 1993), may be partly due to characteristics of the Chinese language and the stimuli we had used in this study.

It may be that the monosyllabic verbs we chose for the present study allowed semantic processes to be early, because it takes less time to process the semantic information encoded in monosyllabic than that contained in polysyllabic words. This view is supported by a recent auditory study in Cantonese in which one-syllable semantically incongruous words elicited an N400-like effect with a maximum over frontal sites at 300 ms following word onset (Schirmer et al., 2005).

It is also possible that our early onset of the semantic effect results from the considerable context dependency inherent in our materials. As the first clauses of our experimental sentences provided top-down context information, the semantic expectation of a particular word may be formed on the basis of the preceding context. The incoming phonological information may have been matched against the phonological template of the expected word. In such a condition, the recognition of the incongruent verb may be influenced by the preceding sentence context (the first

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that both semantic and syntactic processing problems induce integration difficulties in the N400 time window. The absence of the P600 in the combined condition may be caused by a component overlap between the posterior positivity and the broadly distributed negativity in the N400 time window, which was enlarged by the wrap-up effect (Hagoort, 2003).

The parallel and independent processing pattern of the early syntactic and semantic processes and the absence of the P600 in the combined condition were similar to effects reported by Gunter et al. (1997, 2000). Gunter et al. (1997) ob-

5.3. Semantic ratings

Forty subjects who did not participate in the ERP experiment performed the two semantic ratings discussed above. Half of the subjects filled out the first questionnaire in which the first clauses and the verbs of syntactically incorrect sentences and the combined incorrect sentences were printed in written form. Subjects were instructed to indicate on a seven-point scale how compatible the verb (the crucial word) was with the first clause (1 = not compatible; 7 = highly compatible). The compatibility rating revealed that the

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the slash representing the semantically violated one. The combined incorrect sentences are created by eliminating the NP from their semantically counterparts.

1 园丁整理花坛，把杂草拔/薅了。
To make the parterre neat, the gardener pulled out/butchered the weed.

2 邻居掉换工作，把家搬/撤了。
After changing the job, the neighbor moved/withdrew house.

3 小伙子找到对象，把婚事办/印了。
After finding true love, the young man had/printed a wedding

4 值日生清扫教室，把黑板擦/截了。
When cleaning the classroom, the student on duty cleaned/intercepted the blackboard.

5 设计师制作新衣，把布料裁/做了。
To make new dresses, the stylist cut/hewed the cloth.

6 矿工进入矿井，把煤采/分了。
After entering the mine, the miners excavated/distributed coal.

7 施工队拓宽马路，把旧房子拆/扳了。
To make the street wider, the builders broke/pulled out old

8 部队击退敌军，把前哨撤/砸了。
After beating the enemy, the army withdrew/smashed the vaunt-courier.

9 老农喷上农药，把害虫除/杀了。
Using pesticide

10 学生参加考试，把考卷答/丢了。
When attending the examination, the students answered/threw away

11 老王打完草稿，把底稿[illegible]了。
After scribbling, Lao Wang [illegible]

12 人流涌上街道，把路口堵/除了。
Gathering on the street, people jam

13 人们过春节，把鞭炮放/燃了。
In spring festival, people set/ignited/washed the firecracker

14 兄弟俩死了父亲，把家产分/掉了。
After the death of their father, the brothers divided/defaced the bequest.

15 妈妈补衣裳，把袖子缝/拆了。
When mending the dress, the mother sewed on/broke the sleeves.

16 爷爷听取意见，把老习惯改/修了。
Following advices, the grandfather changed/jammed his old habit.

17 骗子坑了许多人，把巨款拐/蒸了。
After befooling many people, the bilker got/lost a lot of money.

18 电工修理机器，把焊锡/漆抹了。
When repairing, the electrician soldered/varnished the machine.

19 老人感到口渴，把矿泉水喝/咽了。
Feeling thirsty, the old man drank/eat the mineral water.

20 儿子买电脑，把钱花/漏了。
The son spent/left the money on computer.

21 同学来到图书馆，把书还/答了。
Coming to the library, the student returned/answered the book.

22 小张做早餐，把鸡蛋煎/杀了。
To making breakfast, Xiao Zhang fried/killed the eggs.

23 海关检查货物，把走私品查/放了。
In customs inspection, the Customs House intercepted/freed the contraband.

24 为建高架桥，把行道树[illegible]
To get timber, the carpenter sawed/sweept the stump.

25 检查员清查危险品，把[illegible]
When checking dangers, the inspector [illegible] parcel post.

26 伐木工开采森林，把松树砍/栽了。
Exploiting the forest, the timberjack hewed/cut pine trees.

27 老汉走路摔到，把牙磕/做了。
Falling on the road, the old man broke/made the teeth.

28 顾客走得匆忙，把皮包落/送了。
Leaving in a hurry, the buyer left/sent the bag.

29 处理交通事故，把车拿下/拔了。
Dealing with the traffic accident, the policeman stopped/moved the car of the peacebreaker.

30 作者写作疏忽，把标点漏/填了。
Writing carelessly, the author neglected/filled the punctuation

31 小赵缺钱，把金戒指卖/掉了。
Lacking money, Xiao Zhao sold/spent the golden ring.

32 消防队赶到现场，把火灭/拆了。
Coming to the locale, the firemen put out/cleaned the fire.

33 店小二拿着抹布，把灰尘抹/灭了。
Taking a piece of duster cloth, the waiter cleaned/erased the dust.

34 摄影师架起相机，把风景拍/采了。
Setting up the camera, the photographer [illegible] the landscape.

35 法官听完陈述，把案子判/破了。
After hearing the statement, the justicer judged/broke the case.

36 运动员超常发挥，把记录做/动了。
Going beyond himself, the game athlete broke/cut the record.

37 匪徒手持枪械，把银行抢/卖了。
Holding the guns, the bandits robed/sold a bank.

38 小偷溜进财务室，把保险柜撬/开了。
Entering the finance office secretly, the stealer prized/judged the strongbox.

39 主人招待客人，把西瓜切/削了。
Serving guests, the host cut/pared the watermelon by knife.

40 女孩追求时尚，把头发染/缝了。
Following the fad, the girl dried/sewed the hair.

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