

Processing of wh-questions in Standard Indonesian: evidence from ERPs

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Research with ERPs has investigated the processing of wh-questions in several languages, such as English, known to be a "wh-movement" language [1] [2], as well as wh-in-situ languages like Japanese [3]. The displaced wh-element is referred to as a "filler," and its original position is called a "gap." These elements are dependent on each other for successful sentence interpretation. The processing of "filler-gap dependency" is associated with the left anterior negativity (LAN) [4] [5]. However, some studies have found P600 instead of LAN at the gap [6] [7]. On the other hand, a study in Japanese [3] did not find any P600 but observed a right-lateralized ERP equivalent of the LAN (RAN). Under long-distance wh-dependency conditions, N400 has also been observed in the pre-gap area [2]. Others reported multiple effects, with a combination of LAN and P600 in wh-questions [1] as well as scrambled wh-questions [8]. One limitation is the rigid word orders of languages (e.g., English) restricting the position for the wh-word when forming the sentence.

In order to address the contrasting results between studies on wh-questions, we test the processing of wh-questions in a language that allows word order flexibility [9] in forming questions: Standard Indonesian (SI). In SI, wh-phrases undergo overt syntactic movement to the sentence-initial position of scope interpretation, [Spec, CP], to form wh-questions (Table 1 (1)), but they can also remain in-situ. Yes/no questions can be similarly generated with comparable structure with the question marker *-kah* appears in various positions, including the wh-phrase (2). However, this cannot be attached on in-situ wh-phrases [10], so 'that' is used instead with the question marker (4). We compared ERPs at the question word for wh-in-situ (3) and its yes/no equivalent (4) and at the verb for the wh-question (1) and yes/no comparison (2).

Our experiment comprises 100 sentences, with 25 questions per condition. Each sentence was preceded by a short context phrase (e.g., "According to the neighbor..."). Using a 64-channel EEG system, we tested 105 right-handed healthy native Indonesian speakers. Sentences were visually shown through rapid-serial-presentation; each word was presented in the centre of the screen for 500ms, with 100ms gap between words, and a comprehension question followed each trial to ensure participants actively read the stimuli.

Using cluster-based permutation tests (with time windows of 300-500ms for N400/LAN and 500-700ms for P600), a broadly distributed negative shift was observed for both wh-conditions when compared to the yes/no equivalent in the 300-500ms time window: on the question word, the wh-in-situ (3) compared to the yes/no equivalent (4) with the cluster starting at around 300ms ($p < .01$) (Figure 1); and on the verb, 'scrambled'-wh (1) compared to the yes/no equivalent (2) with the cluster starting at around 350ms ($p = .02$) (Figure 2). As for the P600 time window, we did not observe an effect in the wh-in-situ comparison, but there is a significant positive wave across most of the recorded channels for (1) when compared to (2) with the cluster starting at around 500ms ($p < .01$) (Figure 3). Our results show filler-gap processing (1 & 2) in SI elicits a negative shift in the N400 time window. The negative shift is argued to index increased working memory load [11] as the parser needs to store the filler until the gap position. The question word ERP found in (3) is similar to the larger N350 for question words observed in Japanese [3]: it peaks at around 350ms (Figure 2), it is slightly left-lateralized, and it is attributed to the individual lexical factors separating the two words. The positive shift in the 500-700ms time window at the verb for the moved wh-particle (1) but not wh in-situ (3) is consistent as the P600 is associated with the syntactic integration of wh-fillers [7]. This is also reflective of the in-situ results from Japanese [3], which reported no P600 effects as Japanese wh-words remain in-situ: there is nothing to retrieve or syntactically integrate.

Table 1. Stimuli list for the study

Wh	1.	Apa	yang	si	bocah	nakal	itu	lempar	kemarin?
		what	REL	the	child	naughty	that	throw	yesterday
Yes	2.	Apakah	si	bocah	nakal			melempar	itu kemarin?
/no (Wh)		what(+QUES)	the	child	naughty			ACTthrow	that yesterday
Wh-in-situ	3.	Si bocah	nakal	itu	melempar			apa	kemarin?
		the child	naughty	that	ACTthrow			what	yesterday
Yes	4.	Si bocah	nakal	itu	melempar			itukah	kemarin?
/no (Wh-in-situ)		the child	naughty	that	ACTthrow			that(+QUES)	yesterday
	1, 3:	What did the naughty child throw yesterday?							
	2, 4:	Did the naughty child throw that yesterday?							

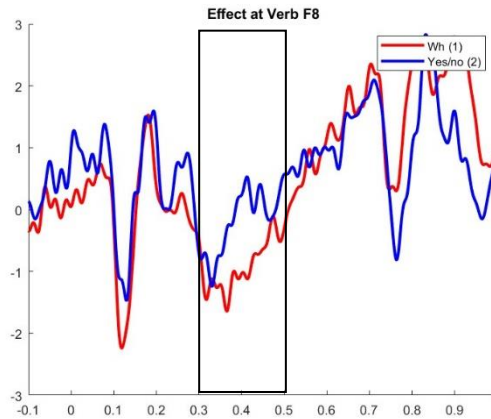


Figure 1. ERP at Verb showing sig. negativity at the 300-500ms time window (F8) for scrambled condition.

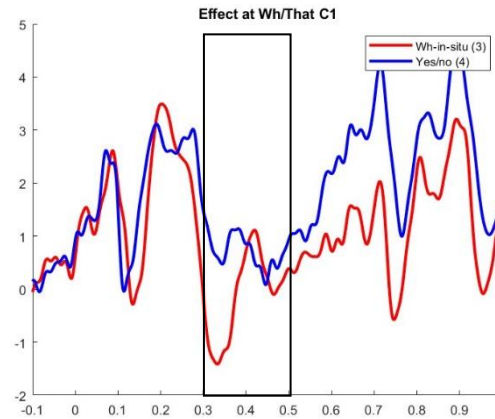


Figure 2. ERP at Wh/that showing sig. negativity at the 300-500ms time window (C1) for wh-in-situ condition.

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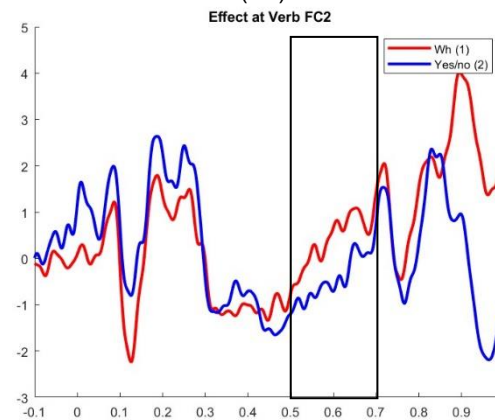


Figure 3. ERP at Verb showing sig. positivity at the 500-700ms time window (FC2) for scrambled condition.