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Loanwords from English to Malay in the Field of Mathematics*

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Four samples of mathematical terms were chosen randomly from the indexes of four tertiary level mathematics textbooks. The mathematical textbooks were selected to cover a wide range of mathematical knowledge. The translations of the terms into the Malay language were found, and by comparing the English terms with their Malay equivalents, the latter were sorted into different categories of loanword type. A chi-squared test was performed to discover if there was a difference between the four samples, in terms of the predominance of different types of loanwords amongst them. No significant difference was found between the four mathematical subject areas in terms of their tendencies towards different types of compound loanwords. This is in contrast with the case for single-word loanwords, where strong evidence was found for a difference. In particular, the language of Calculus and Analysis tends to produce non-loanwords or semantic extensions more often than that of Algebra or Statistics. There was also a difference between Algebra and Statistics in terms of their proportions of orthographically assimilated loanwords. Another test was performed which revealed that mathematical terms generally have different tendencies from those observed in the language as a whole. Mathematical loanwords tend to be more similar to their English equivalents than do general terms. This result has a high degree of statistical significance.

Key words: Malay, mathematics, loanwords

1. Introduction

The aim of this study is to examine loanwords from English to Malay in the field of mathematics. Two specific questions will be asked and answered regarding the tendencies of mathematical terms towards different types of loanwords. The first

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question is whether or not there is a difference between different fields of mathematics in these tendencies; the second question is whether or not mathematical language differs from the language at large.

Generally speaking, the study of loanwords is of interest since it reveals the origins of the words in a language, and reveals past and present trends in a language's development. The Malay language has a great number of terms which have been borrowed from other languages, such as Sanskrit, Arabic, Dutch, Indonesian, Javanese, Siamese, Tamil, Portugese, Chinese dialects and English, amongst others (Tham 1970). Of these, the influence of English has been one of the most recent (Heah 1989:3). The reader interested in the general influence of English on Malay is referred to Heah's 1989 work (ibid.). An excellent reference on the lending process in general is (Weinreich 1953). Mior Hamzah and others (Mior Hamzah et al. 1992) have put together a volume which would be very useful to those interested in the etymology of modern Malay scientific terminology.

In recent years, a number of studies similar to the current one have been performed. Studies of the influence of English on the Malay language have been done in the area of legal terminology (Puteri Roslina 1994), library terms (Che Putih Ismail 1996), and sports terms (Mohd Azemi 1997).

Studies such as these are useful in that they are a small step towards understanding the lending process generally, and particularly into Malay. They are a step towards understanding current trends in the Malay language, and therefore can help linguists infer what may happen to the language in the future. Our study into mathematical terminology may be of assistance to the already strong translation efforts underway in Malaysian universities. It could conceivably also be of interest to a researcher into the etymology of mathematical terms in English.

2. Methodology

For the purpose of this study, four tertiary-level mathematics textbooks were chosen. The textbooks were Anderson's *Introduction to Statistics Concepts and Methods* (Anderson et al. 1994), Fraleigh's *A First Course in Abstract Algebra* (Fraleigh 1982), Marsden's *Elementary Classical Analysis* (Marsden 1974) and Stewart's *Calculus* (Stewart 1995). The books were selected so as to cover a wide range of mathematical topics. We shall henceforth refer to them as *Statistics*, *Algebra*, *Analysis* and *Calculus* respectively. The terms in the index of each textbook were counted and numbered, and a random number generator was used to select 50 lexical items from the index of each book, for a total of 200 English language mathematical terms.

For each of these terms, the corresponding term in the Malay language was found by consulting English-Malay technical dictionaries (DBP 1992, Nik Ahmad et al. 1991). The terms not found in either dictionary were translated into Malay via consultation with Malay-speaking mathematicians.

The Malay language terms were then compared with the English language terms, and classified according to the type of loanword. There were two broad classes, the single-word loanwords (81 terms), and the compound loanwords (119 terms). With the first class, the 'types' of loanwords were non-loanwords, nuclear loanblends, marginal loanblends, orthographically assimilated loanwords, truncated loanwords, wholly assimilated loanwords, partially assimilated loanwords, unassimilated loanwords and semantic extensions. Amongst the compound loanwords there were the fused compounds, the nuclear compound loanblends, the marginal compound loanblends, the analysed compound loanblends, literal loan translations and syntactic substitutions. This classification is modeled closely after that of (Heah 1989), to which the reader is referred for definitions. A list of the mathematical terms, with their translations and their classification into these types, may be found in the Appendix.

The two classes (single-term loanwords and compound loanwords) were analysed separately. The reason for analysing each class separately was that if the classes were analysed together, a tendency for one book to lean towards certain loanword types might reflect a tendency of the author of the book to be verbose or succinct in his or her index, rather than any real tendency in the mathematical language. In each class, a contingency table was set up stating the number of loanwords of each type in each book. The intention was to analyse the data using a chi-squared test to determine if there is any difference between the books in terms of their tendencies towards various loanword types. To this end, some of the 'type' categories needed to be merged, since there were too few words in the individual categories to draw meaningful conclusions from the statistical test.

The categories so merged were as follows: Amongst the single-word loanwords, the 'non-loanwords' category was merged with the 'semantic extensions' category, the 'orthographically assimilated loanwords' were left as a category by themselves, and the other single-word loanword categories were all merged together to form a single group called 'others'. Amongst the compound loanwords, the 'literal loan translations' category was merged with the 'syntactic substitutions' category, 'nuclear compound loanblends' with the 'marginal compound loanblends', and the 'analysed compound loanblends' was left in a category by itself. Out of the 200 terms, only one was classified as a fused compound, namely *self-adjoint* (from *Analysis*), which in Malay becomes *swadampingan*. Since this category could not be sensibly merged with any of the others, and since no statistically significant conclusion whatsoever can be drawn from a single datum in a category by itself, it was decided reluctantly to omit this item from the analysis. The final categories and data may be seen in Tables 1 and 2, below.

The chi-squared test used to analyse the data is a standard statistical technique, so it will not be detailed here. The interested reader may consult Section 16.2 of (Anderson 1994), or any other good statistics book.

After the initial analysis, it was decided to compare the mathematical terms overall with general terms, to see if mathematical terms have different tendencies towards certain loanword types than does the general language. The data for the general language was taken from (Heah 1989). Again, the data from the mathematics textbooks had to be regrouped, this time to fit the categories given in the latter work. The categories and data may be seen in Tables 4 and 5 below. The data was once again analysed using a standard chi-squared test.

3. Results

The data from the four books is given below. Table 1 lists the numbers of single-word loanwords of various types in the various books, and Table 2 lists the numbers of compound loanwords.

Table 1: Single-word loanword frequencies between the four mathematics textbooks

	Algebra	Calculus	Analysis	Statistics	Total
Non-loanwords or Semantic Extensions	10	9	19	7	45
Orthographically Assimilated Loanwords	12	3	4	1	20
Others	2	2	4	8	16
Total	24	14	27	16	81

Table 2: Compound loanword frequencies between the four mathematics textbooks

	Algebra	Calculus	Analysis	Statistics	Total
Analysed Compounds	4	10	5	9	28
Nuclear/Marginal Compound Loanblends	13	10	6	5	34
Literal Loan Translations or Syntactic Substitutions	9	16	11	20	56
Total	26	36	22	34	118

The chi-squared test statistic for the single-word loanword data comes to 21.59, yielding a p-value of 0.0014. This indicates that there is strong evidence of a significant difference in the tendencies for the mathematics books towards different types of single-word loanwords.

For the compound loanword data, the test statistic comes to 9.487, yielding a p-value of 0.148. This means that our study uncovered no evidence of a difference between the four subject matters in terms of their tendencies towards different types of compound loanwords.

For the single-word loanwords, we can discover more about the tendencies by examining the percentages of different types of single-word loanwords (Table 3). The Calculus and Analysis books had higher percentages of non-loanwords and semantic extensions than the Algebra and Statistics books, the Statistics book had a much lower proportion of Orthographically Assimilated loanwords, and the Algebra book a much higher one.

Table 3: Percentages of various single-loanword types for the four mathematics textbooks

	Algebra	Calculus	Analysis	Statistics	Overall
Non-loanwords or Semantic Extensions	42%	64%	70%	44%	56%
Orthographically Assimilated Loanwords	50%	21%	15%	6%	25%
Others	8%	14%	15%	50%	20%

The data for mathematical terms (overall) versus general terms is shown in Table 4 (single-word loanwords) and Table 5 (compound loanwords).

Table 4: Single-word loanword frequencies for mathematical terms and for general Language

	General Terms	Mathematical Terms	Total
Orthographically Assimilated Loanwords	643	20	663
Unassimilated Loanwords	1211	7	1218
Partially or Wholly Assimilated Loanwords	596	5	601
Others	159	4	163
Grand Total	2609	36	2645

Table 5: Compound loanword frequencies for mathematical terms and for general language

	General Terms	Mathematical Terms	Total
Analysed Compounds	286	28	314
Nuclear/Marginal Compound Loanblends	860	34	894
Literal Loan Translations	1336	46	1382
Syntactic Substitutions	341	10	351
Grand Total	2823	118	2941

Calculation of the chi-squared test statistics for these sets of data yields 21.85 for the single-word loanwords, and 22.63 for the compound loanwords. These yield p-values of 0.00007 and 0.000048 respectively -- both indicating a highly (statistically) significant difference between the tendencies of general terms and of mathematical terms. An examination of the relevant percentages (Tables 6 and 7) reveals the nature of this difference. Amongst the single-word terms, mathematical loanwords into the Malay language have a tendency towards being orthographically assimilated, and tend not to be unassimilated. Amongst the compound loanwords, the tendency is towards analysed compounds. On average, mathematical terms are less likely to be syntactic substitutions or literal loan translations than general Malay language loanwords from English.

Table 6: Single-word loanword percentages for mathematical terms and for general language

	General Terms	Mathematical Terms
Orthographically Assimilated Loanwords	25%	56%
Unassimilated Loanwords	46%	19%
Partially or Wholly Assimilated Loanwords	23%	14%
Others	6%	11%

Table 7: Compound loanword percentages for mathematical terms and for general language

	General Terms	Mathematical Terms
Analysed Compounds	10%	24%
Nuclear/Marginal Compound Loanblends	30%	29%
Literal Translations	47%	39%
Syntactic Substitutions	12%	8%

4. Conclusion

In this study, we have examined the tendencies of mathematical loanwords from English in Malay. The aim was to determine if different branches of mathematics have different tendencies towards various loanword types, and if the tendencies for mathematical terms are different from those of the language overall. The clearest pattern discovered was that mathematical terms in Malay tend to be more similar to their English counterparts than do general terms. This is seen most explicitly amongst the single-loanword percentages (Table 6), and confirmed amongst the compound loanword percentages (Table 7) -- our sample of mathematical terms contained 8% fewer literal loan translations than the language at large, and 14% more analysed compounds.

This may imply that mathematical terms in English tend to be terms in their own right, rather than being semantic extensions of other English terms. If this idea is correct, it would explain our data for compound loanwords -- for translators faced with no natural Malay equivalent to a term can reasonably be expected to form a new Malay word based on the English one. On the other hand, our data may reflect a desire on the part of a translator to make Malay language technical terms similar to their English equivalents. In this case, a translator who could choose an existing Malay term to cover the new concept might choose instead to form a new Malay term, as close to the source language as possible.

There are indeed two current schools of thought regarding this kind of choice (Zubaidi 1992). Some see borrowing as a bad thing, an unavoidable corruption of the language. Others see it as a good thing, a way the language can be enriched. Sharir points out, in (Sharir 1992), that the latter school of thought appears to predominate amongst translators of mathematical works into Malay. He also gives some indications

of the reasons why this should be so, pointing out that a lack of borrowing in the past led to confusions and inconsistencies in the Malay mathematical lexicon.

Single-word loanwords include far fewer unassimilated loanwords than the general language. This is probably due to the fact that many unassimilated loanwords in the Malay language are in fact product brand names (such as *McDonalds* or *Shell*) (Heah 1989:101). Brand names are comparatively rare in the mathematical lexicon! Note however, that our data appears to conflict with certain statements made by Heah (ibid. p.100). She states:

> Another area with a heavy concentration of unassimilated English loanwords is, not surprisingly, the technical sphere.

Perhaps mathematical loanwords do not follow the tendency of technical language generally. Certainly the process of importation of scientific terms has been ongoing for some decades (Sulaiman 1989:124). According to (Heah 1989:101), this may well explain the discrepancy.

Less clear was the pattern of differences between the four different subject matters chosen. In fact, amongst the compound loanwords, we found no evidence for any difference in the tendencies. Amongst the single-word loanwords, however, it was noted that the language of Algebra or Statistics has fewer non-loanwords (or semantic extensions) than that of Calculus or Analysis, and also that Algebra appears to have many orthographically assimilated loanwords, whereas Statistics has relatively few.

The reason for this tendency amongst the Algebra terms is easy to understand -- many English language terms in Abstract Algebra are themselves loans from other languages (such as *epimorphism* from Ancient Greek or *surjection* from French). These terms generally have no alternative nonmathematical meaning, leading to a greater tendency towards loaning generally and orthographic assimilation in particular when these concepts are imported into Malay.

The other differences are harder to explain. Statistics deals with randomness and probability, Analysis and Calculus with functions, curves and shapes, and algebra with abstractions of ordinary operations and sets. Perhaps because some concepts from Analysis and Calculus are easier to ‘visualise’, the Malay language already had terms available ready to be extended to cover the new concepts in these fields.

On the other hand, some statistical terms such as *normal* or *experiment* have been brought into Malay either unassimilated (*normal*) or partially assimilated (*eksperimen*), when the concepts could quite reasonably have been brought into the language via a semantic extension (such as *biasa* for *normal*), or by a more native construction (such as *ujikaji* for *experiment*). This tendency, if real, would also explain our data. The only

question remaining would be why this 'policy' was adopted for statistics, and less so for Analysis or Calculus.

Some statistical terms were classified as 'wholly assimilated', due to their existence in Malay language dictionaries from the 1970's (Teuku Iskadar 1970). Others (such as *normal*, *histogram* and *plot*) are unassimilated, rather than orthographically assimilated, simply because their spelling in English is highly compatible with Malay, obviating the need for adaptation. These historical and linguistic accidents, we feel, form the most likely explanation for the difference between the data for Algebra and for Statistics. It should also be pointed out that to carefully distinguish an orthographically assimilated (or other) loanword from a wholly assimilated one is impossible from the spelling alone, and in general requires a careful historical survey. Performing such a survey for each of the terms being analysed was beyond the scope of this study.

The questions and hypotheses mentioned above suggest some possible avenues for further research. It would also be interesting to extend the study to other fields of knowledge closely related to mathematics, such as physics and chemistry or computer science.

Appendix

List of words used in the analysis:

Table 8: Algebra terms:

English term:	Malay equivalent:	How classified:
adjunction	adjungsi	orthographically assimilated loanword
affine group	kumpulan afin	marginal compound loanblend
algebraic closure	tutupan algebra	marginal compound loanblend
algebraic number	nombor algebra	marginal compound loanblend
algorithm	algoritma	orthographically assimilated loanword
bijection	bijeksi	orthographically assimilated loanword
binary operation	operasi dedua	nuclear compound loanblend
codomain	kodomain	orthographically assimilated loanword
composition series	siri komposisi	analysed compound loanblend
content of a polynomial	kandungan polinomial	marginal compound loanblend
cyclic notation	tatanda kitaran	literal loan translation
derivative	terbitan-terbitan	semantic extension
descending	menurun	non-loanword
elementary	permulaan	non-loanword
empty set	set kosong	nuclear compound loanblend
empty word	perkataan kosong	literal loan translation
epimorphism	epimorfisma	orthographically assimilated loanword
Euler's theorem	teoem Euler	analysed compound loanblend
even permutation	pilihatur genap	literal loan translation
extension	perluasan	semantic extension
extension field	medan perluasan	literal loan translation
factor	faktor	wholly assimilated loanword
general polynomial	polinomial am	nuclear compound loanblend
geometry	geometri	orthographically assimilated loanword
greatest common divisor	pembahagi sepunya terbesar	syntactic substitution
integer	integer	unassimilated loanword
integral domain	domain integer	analysed compound loanblend
inverse map	peta songsang	literal loan translation
join	cantum	semantic extension
monomorphism	monomorfisma	orthographically assimilated loanword
multiplicity	kegandaan	semantic extension
quaternion group	kumpulan kuarternion	marginal compound loanblend
rational	nisbah	non-loanword
rational function	fungsi nisbah	nuclear compound loanblend
refinement series	siri penghapusan	nuclear compound loanblend
ring	gelang	semantic extension
series	siri	orthographically assimilated loanword

skew field	medan pencong	literal loan translation
structure constants	pemalar struktur	marginal compound loanblend
surjection	surjeksi	orthographically assimilated loanword
theorem	teorem	orthographically assimilated loanword
theory	teori	orthographically assimilated loanword
topological space	ruang topologi	marginal compound loanblend
torsion	kilasan	semantic extension
trace	surih	semantic extension
transitive	transitif	orthographically assimilated loanword
union of sets	kesatuan set	marginal compound loanblend
unitary module	modul unitary	analysed compound loanblend
well defined	tertakrif baik	literal loan translation
word problem	perkataan masalah	literal loan translation

Table 9: Analysis terms:

English term:	Malay equivalent:	How classified:
accumulation point	titik tumpukan	literal loan translation
approximation	penghampiran	semantic extension
axiom of substitution	aksiom penggantian	literal loan translation
boundary	sempadan	semantic extension
bounded variation	ubahan terbatas	literal loan translation
characteristic function	fungsi cirian	nuclear compound loanblend
classical mechanics	mekanik klasik	analysed compound loanblend
continuity	keselanjaran	semantic extension
curve	lengkung	non-loanword
Dedekind cuts	potongan Dedekind	marginal compound loanblend
denumerable	terangkakan	semantic extension
distribution	taburan	semantic extension
electrostatic	elektrostatik	orthographically assimilated loanword
equation	persamaan	non-loanword
finite intersection property	sifat persilangan terhingga	syntactic substitution
geometri series	siri geometri	analysed compound loanblend
greatest lower bound	batas bawah terbesar	syntactic substitution
isotropic	isotropi	orthographically assimilated loanword
Jacobian determinant	penentu Jacobian	marginal compound loanblend
jump	lompat	non-loanword
Langrange indentity	indentiti Langrange	analysed compound loanblend
least upper bound	batas atas terkecil	syntactic substitution
metric space	ruang metrik	marginal compound loanblend
multilinear	multilinear	unassimilated loanword
nowhere dense	tak tumpat di mana-mana	syntactic substitution
one to one correspondence	perpadanan satu dengan satu	syntactic substitution
open set	set terbuka	nuclear compound loanblend

path	lintasan	semantic extension
perfect	sempurna	semantic extension
periodic	berkala	non-loanword
point	titik	non-loanword
positive definite	tentu positif	marginal compound loanblend
positive integer	integer positif	analysed compound loanblend
principle	prinsip	truncated loandword
relation	hubungan	semantic extension
relatively compact	padat secara relatif	syntactic substitution
rule	petua	semantic extension
segment	tembereng	non-loanword
self-adjoint	swadampingan	fused compund
space	ruang	semantic extension
standard	piawai	non-loanword
subcover	subtudung	marginal loanblend
subset	subset	unassimilated loanword
symmetric	simetri	orthographically assimilated loanword
tangent	tangen	orthographically assimilated loanword
target	sasaran	semantic extension
trigonometric series	siri trigonometri	analysed compound loanblend
uncountable	tak terbilang	literal loan translation
wave	gelombang	semantic extension
wave equation	persamaan gelombang	literal loan translation

Table 10: Calculus terms:

English term:	Malay equivalent:	How classified:
average rate	kadar purata	literal loan translation
binomial series	siri binomial	analysed compound loanblend
characteristic equation	persamaan ciri	literal loan translation
cissoid	sisoid	orthographically assimilated loanword
comparison test	ujian bandingan	literal loan translation
comparison theorem	teorem perbandingan	nuclear compound loanblend
complex conjugate	konjugat kompleks	analysed compound loanblend
component function	komponen fungsi	analysed compound loanblend
components of a vector	komponen vektor	analysed compound loanblend
convergent	menumpu	semantic extension
cosine function	fungsi kosinus	analysed compound loanblend
critical point	titik genting	literal loan translation
curve	lengkung	non-loanword
derivative	terbitan	semantic extension
differential equation	persamaan pembeza	literal loan translation
divergent series	siri mencapah	nuclear compound loanblend
even function	fungsi genap	nuclear compound loanblend

exponential function	fungsi eksponen	analysed compound loanblend
fluid flow	aliran bendalir	literal loan translation
force	daya	semantic extension
formula	rumus	non-loanword
Gauss' Theorem	teorem Gauss	analysed compound loanblend
gradient vector	vektor kecerunan	nuclear compound loanblend
half	setengah	non-loanword
hyperboloid	hiperboloid	orthographically assimilated loanword
indefinite integral	integer tak tentu	nuclear compound loanblend
infinite series	siri tak terhingga	nuclear compound loanblend
intermediate value theorem	teorem nilai pertengahan	syntactic substitution
intersection	persilangan	semantic extension
level surface	permukaan rata	literal loan translation
limit	had	semantic extension
logistic	lojistik	orthographically assimilated loanword
mean value	nilai min	nuclear compound loanblend
modulus	modulus	unassimilated loanword
normal vector	vektor normal	analysed compound loanblend
notation	tatatanda	semantic extension
order of integration	peringkat pengamiran	literal loan translation
overdamped vibration	getaran lebih lembap	literal loan translation
parabolic cylinder	silinder parabolik	analysed compound loanblend
partial fractions	pecahan separa	literal loan translation
ratio test	ujian nisbah	literal loan translation
rational number	nombor nisbah	literal loan translation
real number	nombor nyata	literal loan translation
rectangular coordinate	koordinat segiempat tepat	nuclear compound loanblend
Rolle's theorem	teorem Rolle	analysed compound loanblend
solid angle	sudut pepejal	literal loan translation
spherical wedge	baji sfera	marginal compound loanblend
tree diagram	gambarajah pokok	literal loan translation
triple	trirangkap	marginal loanblend
twisted cubic	kubik terbelit	nuclear compound loanblend

Table 11: Statistical terms:

English term:	**Malay equivalent:**	**How classified:**
addition rule	petua penambahan	literal loan translation
analysis of variance	analisis varians	analysed compound loanblend
backward elimination	penghapusan ke belakang	literal loan translation
cause and effect relationships	perhubungan sebab dan kesan	syntactic substitution
class	kelas	wholly assimilated loanword
classical method	kaedah klasik	nuclear compound loanblend

complement	pelengkap	semantic extension
confidence coefficient	pekali keyakinan	literal loan translation
data acquisition	perolehan data	marginal compound loanblend
degree of belief	darjah kepercayaan	literal loan translation
distribution-free method	kaedah bebas taburan	literal loan translation
element	unsur	semantic extension
expected value	nilai jangkaan	literal loan translation
experiment	eksperimen	partially assimilated loanword
factor	faktor	wholly assimilated loanword
F-test	ujian-F	literal loan translation
general linear model	model linear am	analysed compound loanblend
grouped data	data terkumpul	nuclear compound loanblend
histogram	histogram	unassimilated loanword
independence	tak bersandar	literal loan translation
independent variable	pembolehubah tak bersandar	literal loan translation
linear regression	regresi linear	analysed compound loanblend
mean	min	orthographically assimilated loanword
measurement scales	skala pengukuran	literal loan translation
multiple comparison	perbandingan berganda	literal loan translation
normal	normal	unassimilated loanword
null hypothesis	hipotesis nol	analysed compound loanblend
observation	cerapan	non-loanword
one-tailed test	ujian satu hujung	literal loan translation
partitioning	pemetakan	semantic extension
plot	plot	unassimilated loanword
population covariance	kovarians populasi	analysed compound loanblend
power	kuasa	semantic extension
prediction interval	selang ramalan	literal loan translation
prior probability	kebarangkalian prior	marginal compound loanblend
probability distribution	taburan kebarangkalian	literal loan translation
qualitative data	data kualitatif	analysed compound loanblend
quantitative data	data kuantitatif	analysed compound loanblend
quartile	kuartil	partially assimilated loanword
ratio	nisbah	non-loanword
robustness	keteguhan	semantic extension
sample mean	min sampel	analysed compound loanblend
sample surveys	tinjauan sampel	marginal compound loanblend
sampling	pensampelan	nuclear loanblend
sampling unit	unit pensampelan	analysed compound loanblend
small sample case	kes sampel kecil	syntactic substitution
type I error	ralat jenis I	literal loan translation
type I error rate	kadar ralat jenis I	literal loan translation
type II error	ralat jenis II	literal loan translation
union of events	kesatuan peristiwa	literal loan translation

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