

計画言語ロジバンの意味論と クワインの哲学

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DDD @ 立正大学大崎キャンパス

計劃言語 planned language

計画言語 planned language

人工言語 artificial language

計画言語 planned language

人工言語 artificial language

simulation?

計画言語 planned language

人工言語 artificial language

simulation?

ars 方法、技術?

計劃言語 planned language

constructed
planned
invented

計画言語 planned language

構築された	constructed
計画された	planned
発明された	invented

計画言語 planned language conlang

構築された	constructed
計画された	planned
発明された	invented

Loglan (1955 -)

James Cooke Brown (1921-2000)



In Beijing, April 1994 (Loglan.org)



Brown (1970) :

The Troika Incident

ユートピア世界

Loglan?

Gottfried Wilhelm von Leibniz (1646-1716)



(The MacTutor History of Mathematics archive)



Brown (1960) :

In the closing decades of the 17th century the philosopher-mathematician Gottfried Wilhelm von Leibniz proposed the development of a "universal symbolism" that would speed the growth of scientific thought in the same dramatic way that the development of mathematics was then advancing the art of scientific computation. As a mathematician,

"Loglan", *Scientific American*.



Brown (1960) :

In the closing decades of the 17th century the philosopher-mathematician Gottfried Wilhelm von Leibniz proposed the development of a "universal symbolism" that would speed the growth

characteristica universalis

普遍的な

記号

"Loglan", *Scientific American*.

Friedrich Adolf Trendelenburg (1802–1872)



Leibnizの仕事を解釈

“Über Leibnizens Entwurf
einer allgemeinen Charakteristik”
(1856)

Friedrich Adolf Trendelenburg (1802–1872)



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Leibnizの仕事を解釈

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characteristica universalis

calculus philosophicus	哲学の計算
calculus ratiocinator	推論の計算
spécieuse générale	一般的な綺麗な表現



Leibniz:

Sed ut redeam ad expressionem cogitationum per characteres, ita sentio nunquam controversias finiri neque sectis silentium imponi posse, nisi a ratiocinationibus complicatis ad calculos simplices, a vocabulis vagae incertaeque significationis ad characteres determinatos revocemur.

Id scilicet efficiendum est, ut omnis paralogismus nihil aliud sit quam error calculi, et ut sophisma, in hoc novae scripturae genere expressum, revera nihil aliud sit quam soloecismus vel barbarismus, ex ipsis grammatices hujus philosophicae legibus facile revincendus.

Quo facto, quando orientur controversiae, non magis disputatione opus erit inter duos philosophos, quam inter duos Computistas. Sufficiet enim calamos in manus sumere sedereque ad abacos, et sibi mutuo (accito si placet amico) dicere: calculemus.

"Vorarbeiten zur allgemeinen Charakteristik",
Die philosophischen Schriften (1890)

Friedrich Adolf Trendelenburg (1802–1872)



Leibnizの仕事を解釈

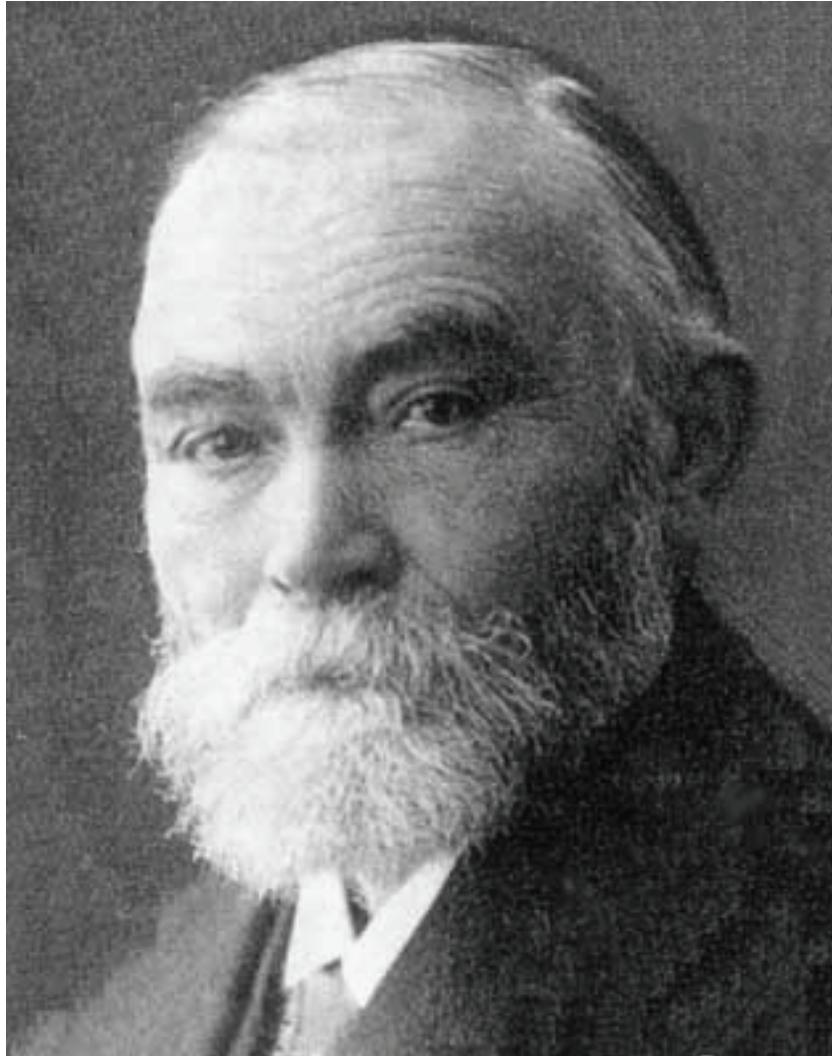
“Über Leibnizens Entwurf
einer allgemeinen Charakteristik”
(1856)

characteristica universalis

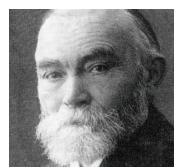
"ユートピア的な性質"
"知識を表現する道具になる"

(論理演算の原始的なものを記号で表す方法)

Gottlob Frege (1848-1925)



*Begriffsschrift,
Eine der arithmetischen
nachgebildete Formelsprache
des reinen Denkens (1879)*

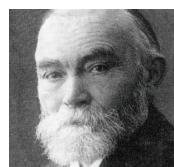


Frege (1879):

Auch Leibniz hat die Vortheile einer angemessenen Bezeichnungsweise erkannt, vielleicht überschätzt. Sein Gedanke einer allgemeinen Charakteristik, eines calculus philosophicus oder ratiocinator*) war zu riesenhaft, als dass der Versuch ihn zu verwirklichen über die blossen Vorbereitungen hätte hinausgelangen können. Die Begeisterung, welche seinen Urheber bei der Erwägung ergrift, welch' unermessliche Vermehrung der geistigen Kraft der Menschheit aus einer die Sachen selbst treffenden Bezeichnungsweise entspringen würde, liess ihn die Schwierigkeiten zu gering schätzen, die einem

*) Siehe hierüber: Trendelenburg, Historische Beiträge zur Philosophie 3. Band.

Begriffsschrift.



Frege (1879):

M's sind P's; oder: „es ist möglich, dass ein *M* ein *P* sei“.

So ergiebt sich die Tafel der logischen Gegensätze:

	$\neg \frac{a}{\Box} P(a)$	conträr	$\neg \frac{a}{\Box} P(a)$
	$X(a)$		$X(a)$
$\forall a (X(a) \Rightarrow P(a))$	s	contra	$\forall a (X(a) \Rightarrow \neg P(a))$
	u	dictorisch	u
	b		b
	a		a
	i		i
	t		t
	e		e
	r		r
$\neg \forall a (X(a) \Rightarrow \neg P(a))$	n	contra	$\neg \forall a (X(a) \Rightarrow P(a))$
		dictorisch	
	$\neg \frac{a}{\Box} P(a)$	conträr	$\neg \frac{a}{\Box} P(a)$
	$X(a)$		$X(a)$



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"Vorarbeiten zur allgemeinen Charakteristik",
Die philosophischen Schriften (1890)

Willard Van Orman Quine (1908-2000)



"Two Dogmas of Empiricism"
(1951)

(The MacTutor History of Mathematics archive)



Quine (1951) :

I do not know whether the statement ‘Everything green is extended’ is analytic. Now does my indecision over this example really betray an incomplete understanding, an incomplete grasp of the “meanings”, of ‘green’ and ‘extended’? I think not. The trouble is not with ‘green’ or ‘extended’, but with ‘analytic’.

It is often hinted that the difficulty in separating analytic statements from synthetic ones in ordinary language is due to the vagueness of ordinary language and that the distinction is clear when we have a precise artificial language with explicit “semantical rules.” This, however, as I shall now attempt to show, is a confusion.

“Two Dogmas of Empiricism”



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“Two Dogmas of Empiricism”



Quine (1953) :

Philip believes that
Tegucigalpa is in Nicaragua.

"VIII. Reference and modality",
From a logical point of view.



Quine (1953) :

Philip believes that
Tegucigalpa is in Nicaragua.

Tegucigalpa = capital of Honduras

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Quine (1953) :

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Tegucigalpa = capital of Honduras

Philip believes that
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"referentially opaque" 指示的に不透明

"VIII. Reference and modality",
From a logical point of view.

Benjamin Lee Whorf (1897-1941)



(Wikipedia)

"the principle of
linguistic relativity"

Wilhelm von Humboldt (1767-1835)



(Wikimedia commons)

"the principle of linguistic relativity"

"the principle of linguistic relativity"

language determines thought

言語が思考を決定づける

"the principle of linguistic relativity"

language determines thought
言語が思考を決定づける



Ludwig Wittgenstein,
Tractatus Logico-Philosophicus (1922) :

5.6 The limits of my language
mean the limits of my world.

"the principle of linguistic relativity"

language determines thought
言語が思考を決定づける



Ludwig Wittgenstein,
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5.6 The limits of my language
mean the limits of my world.

language influences thought
言語が思考に影響する



Brown (1960) :

But Whorf's doctrine, that human thought is largely determined by the formal properties of the pre-existent social forms embedded in the structure of language, is slowly gaining experimental attention. Whorf does not explicitly embrace Leibniz's program of a universal symbolism. Yet implicit in his view of the nature of language is just this possibility. For if language is a human artifact, the power of the human mind need not be restrained by existing languages; the possibility that the inventive "Loglan", *Scientific American*.



Brown (1960) :

its experimental purpose. We cannot be sure that this imitative borrowing from mathematics and logic has maximized Loglan's "ratiocinative power." But we have at least succeeded in achieving a high degree of imitation. It would be surprising if, with such formidable models, Loglan were not superior to any of the natural languages in its ability to facilitate thought, if indeed thought is liable to such facilitation.

"Loglan", *Scientific American*.



Brown (1960) :

「自然言語を使うよりも、Loglanを使う方が、
思考する能力が上がり、Leibnizの理想に近づくはずだ」

「Loglanを使うことによって、
実際に思考する能力が上がっていることが（何らかの方法で）
実証できれば、それはWhorfの言語相対性原理を支持する結果
と言えるはずだ」

"Loglan", *Scientific American*.

lojban (1987-) ver. 1: 1997

lojban (1987-) ver.1: 1997

文法: yacc

lojban (1987-) ver.1: 1997

文法: yacc

→ peg (Parsing expression grammar)

lojban (1987-) ver.1: 1997

文法: yacc

先読み1回

字句解析: 単語をtokenに置き換え

→ peg (Parsing expression grammar)

lojban (1987-) ver.1: 1997

文法: yacc

先読み1回

字句解析: 単語をtokenに置き換え

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先読み無限回

lojban (1987-) ver.1: 1997

文法: yacc

先読み1回

字句解析: 単語をtokenに置き換え

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先読み無限回

文字 자체をtokenとして扱う

lojban (1987-) ver.1: 1997

文法: yacc

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字句解析: 単語をtokenに置き換え

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先読み無限回

文字 자체をtokenとして扱う

字句解析と構文解析を両方ともpegができる

lojban (1987-) ver.1: 1997

重城良国 (2012): cakyrespa

図形を描く亀のゲーム

Haskell で書かれている

入力される lojban 文を peg に従って解析

lojban (1987-) ver.1: 1997

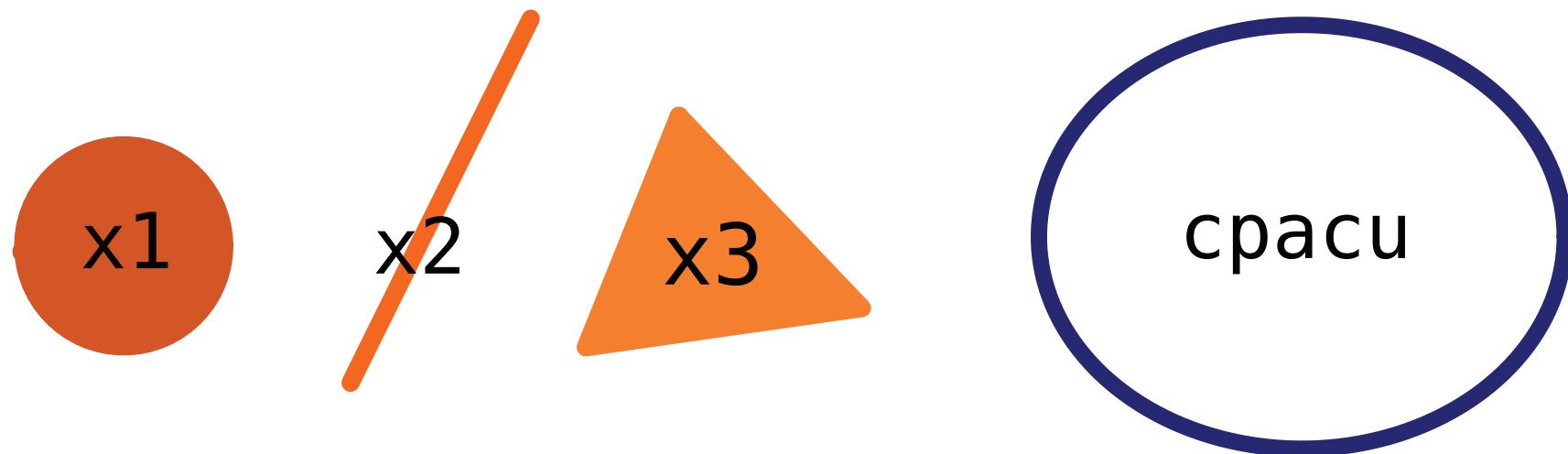
今後の可能性

図形を描く命令以外の文に対する反応の仕方も教える。
(いろいろな反応ができるように)

人工知能にlojbanの各単語の意味を
単語間の関係として教える。
(どんな文を作ってくれるか実験)

lojban (1987-) ver.1: 1997

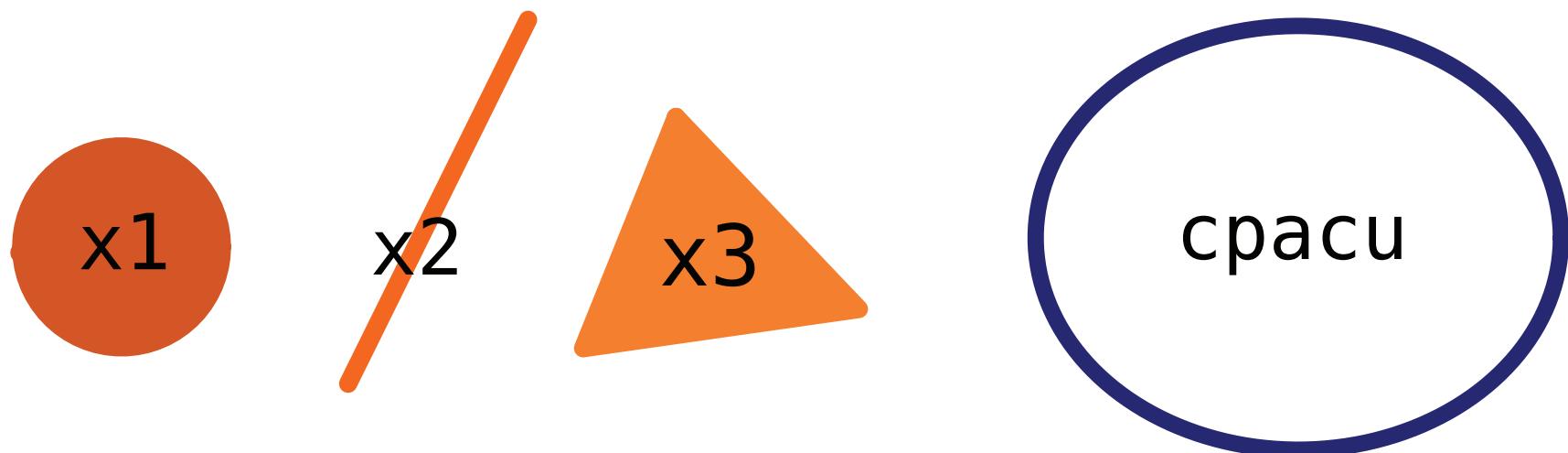
各単語の意味を 単語間の関係として教える。



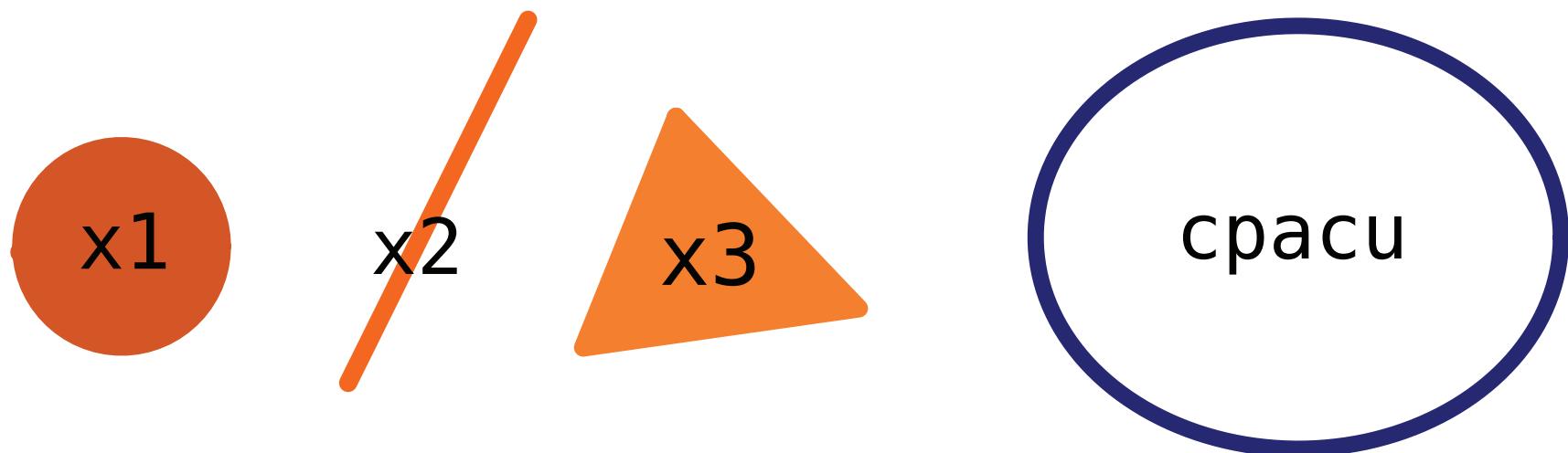
x1は x2（対象）を x3（起源）から入手する

x1 co'a ponse x2 noi x3 krasι ke'a

lojban (1987-) ver.1: 1997

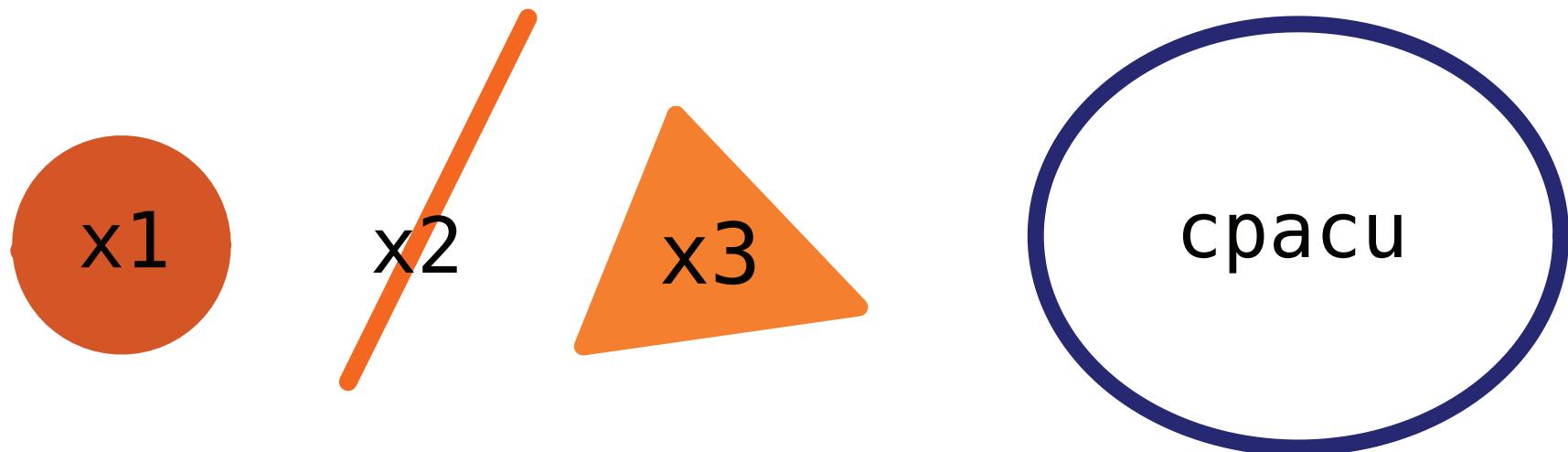


lojban (1987-) ver.1: 1997



C (x1, x2, x3)

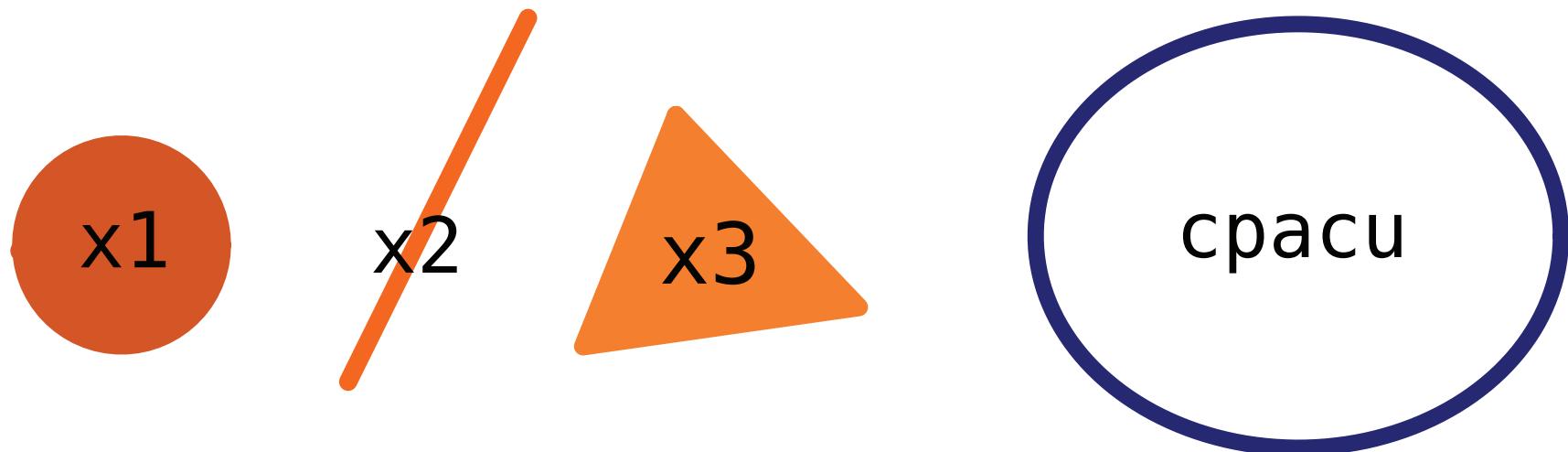
lojban (1987-) ver.1: 1997



C (x1, x2, x3)

cpacu 入手する！

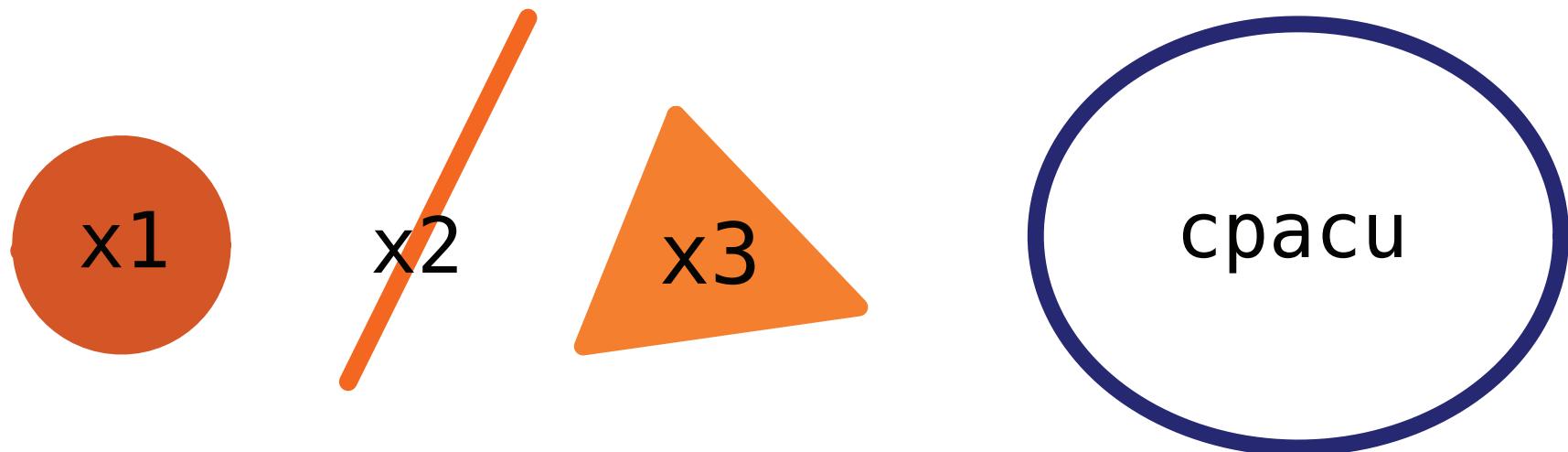
lojban (1987-) ver.1: 1997



C (x1, x2, x3)

cpacu 入手する! "observative"

lojban (1987-) ver.1: 1997



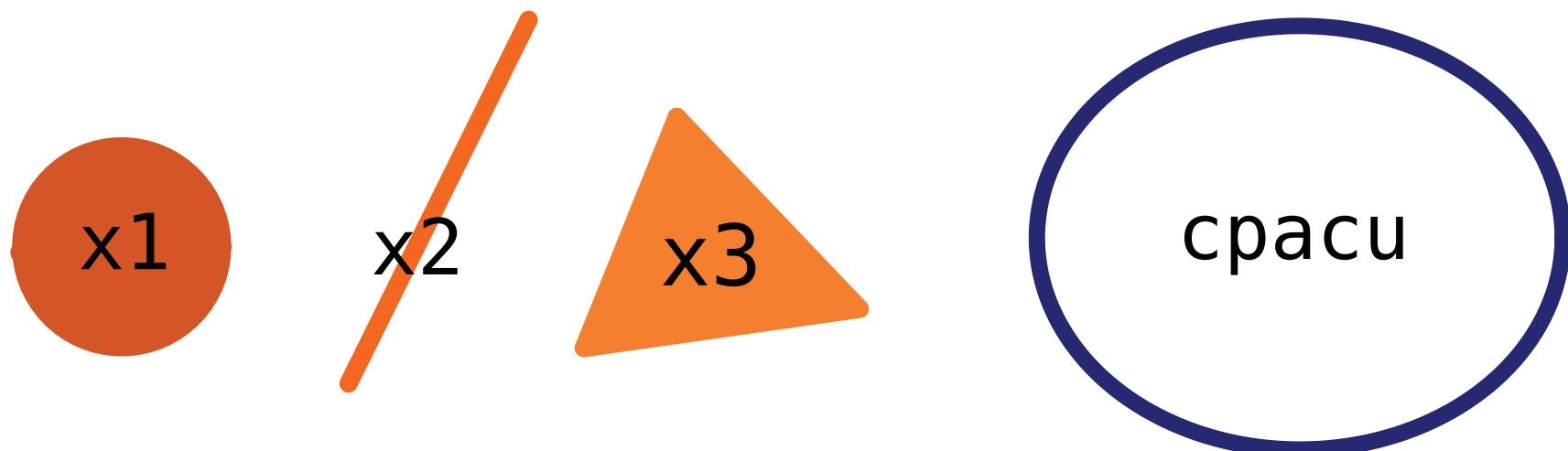
$C(x_1, x_2, x_3)$

cpacu 入手する! "observative"

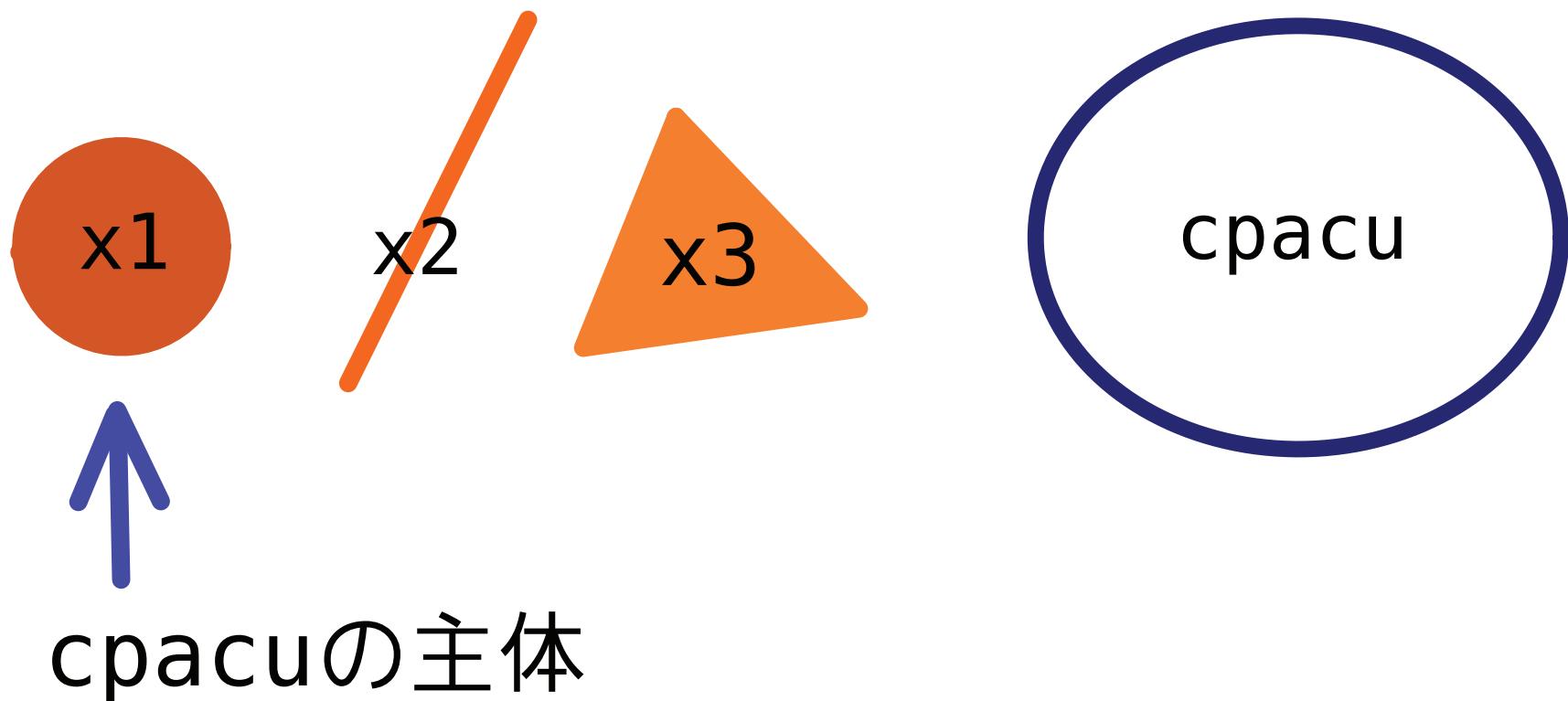


Quine: observation sentence

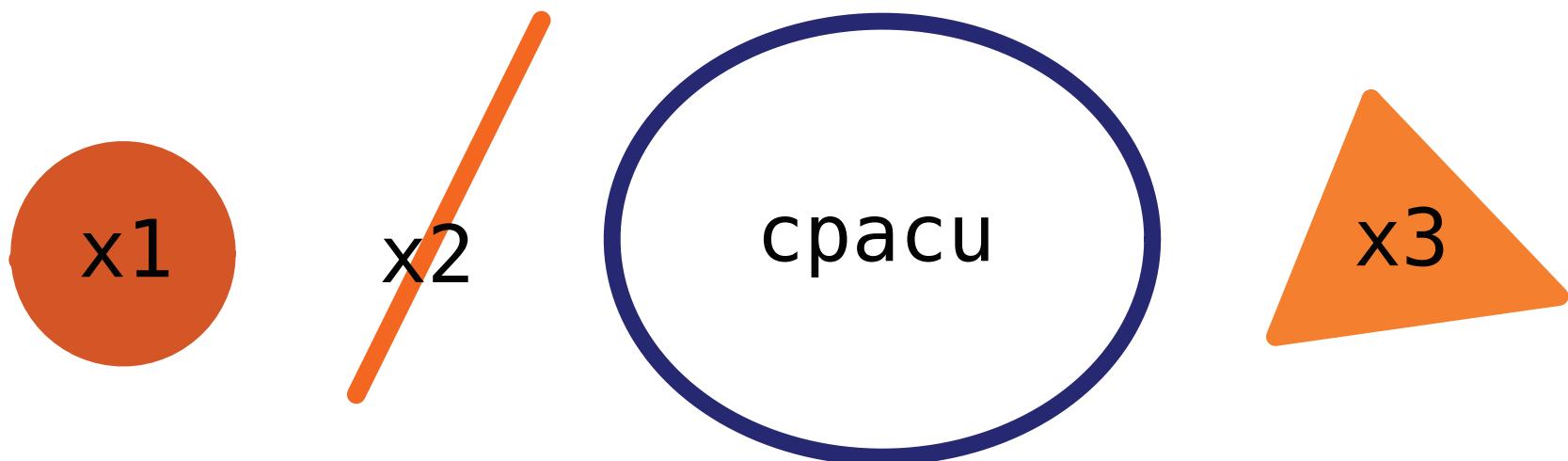
lojban (1987-) ver.1: 1997



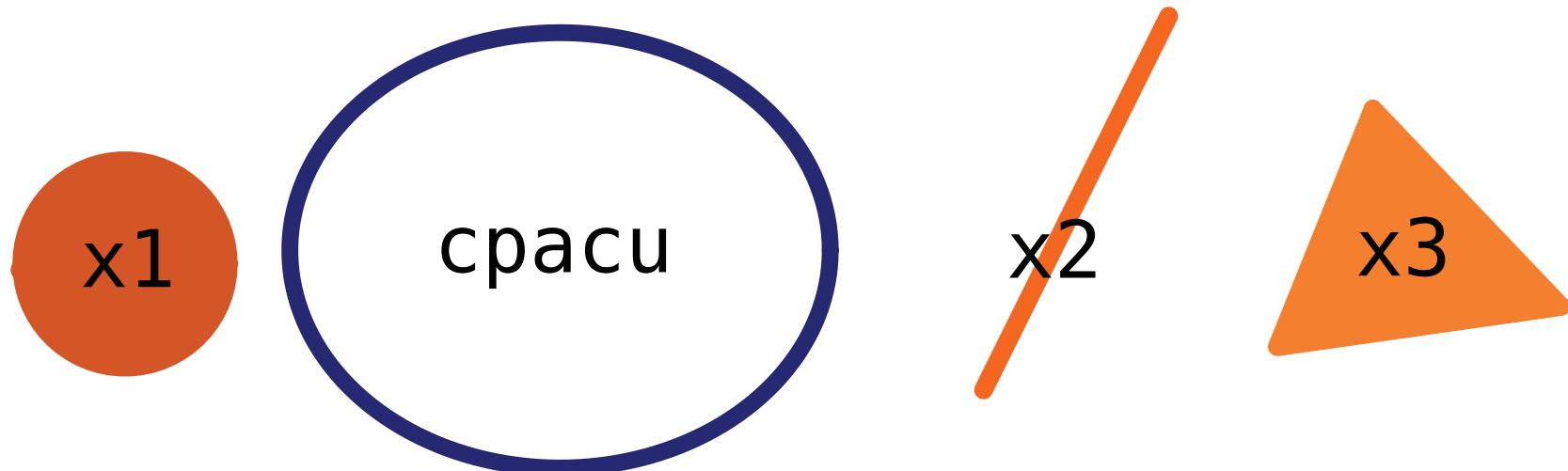
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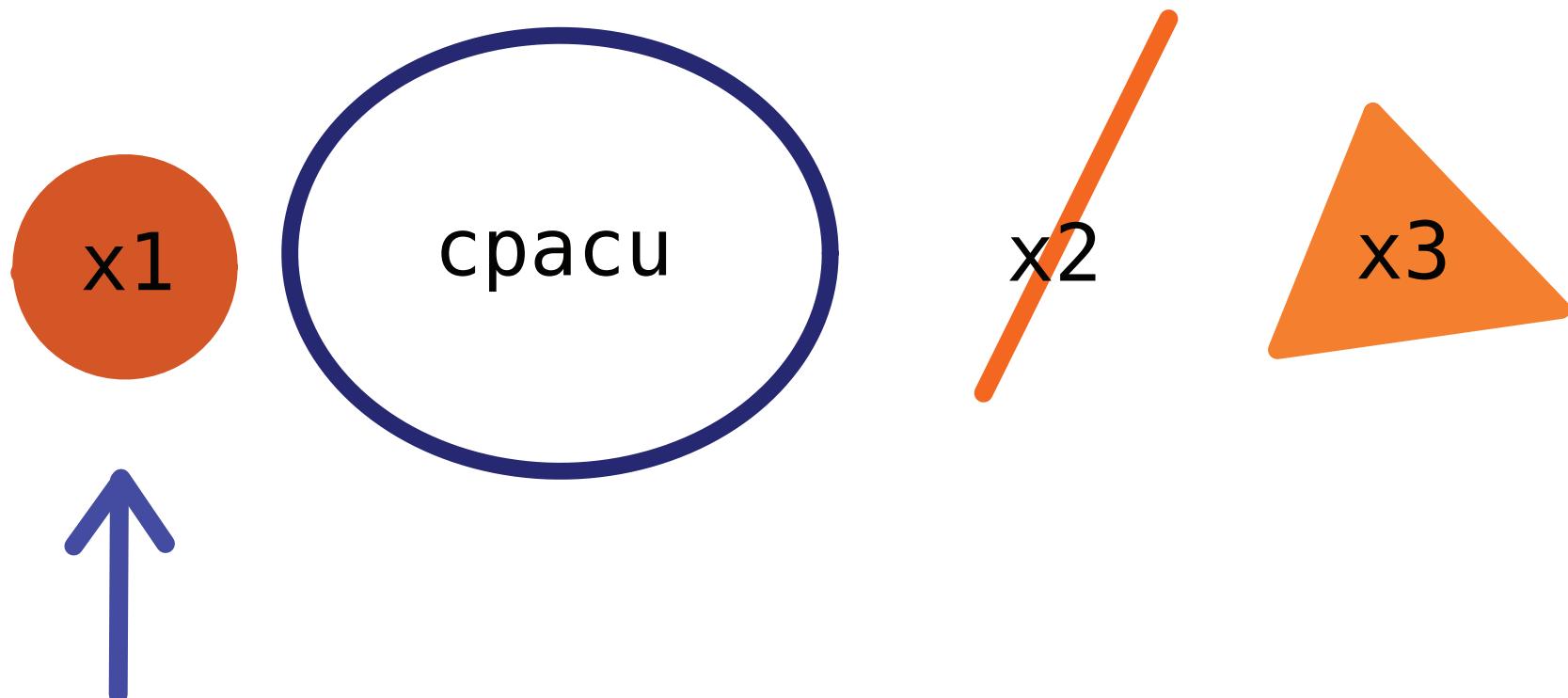
lojban (1987-) ver.1: 1997



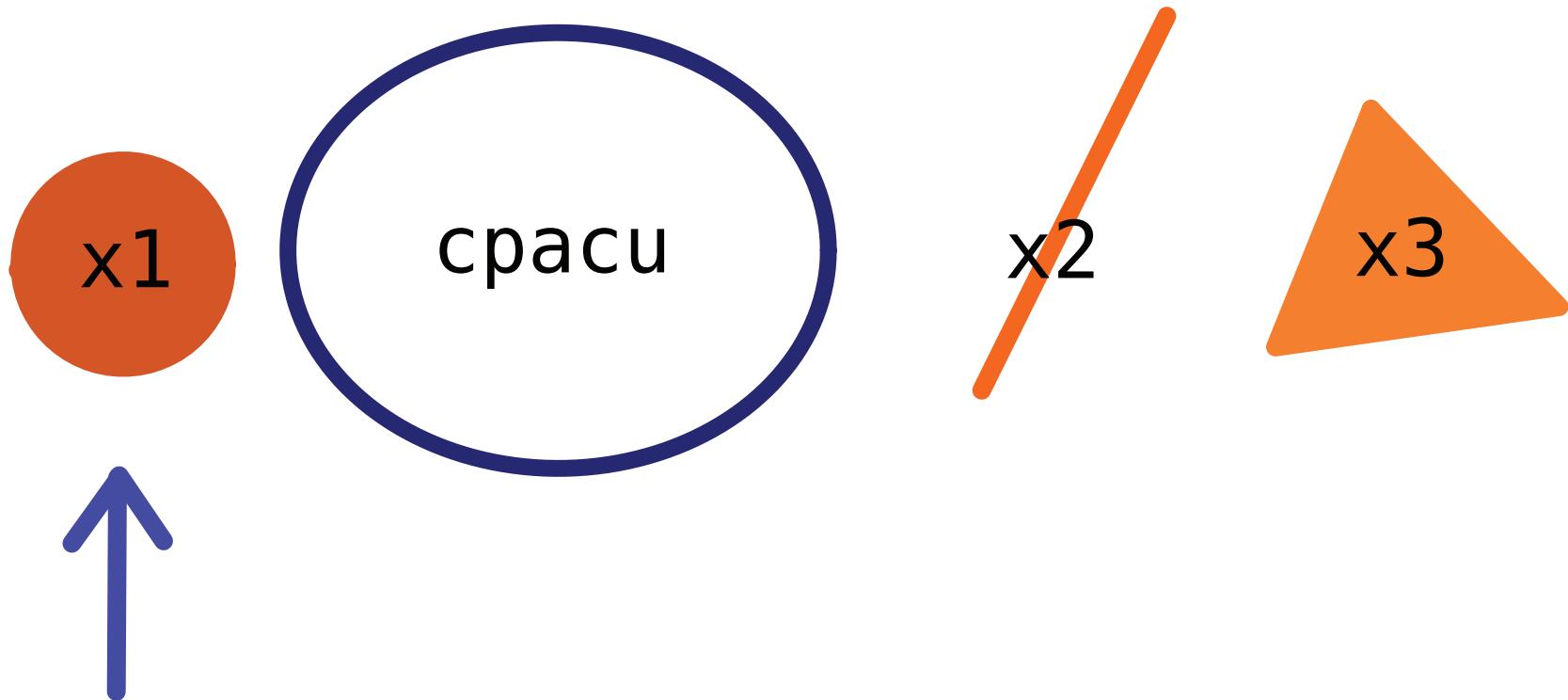
lojban (1987-) ver.1: 1997



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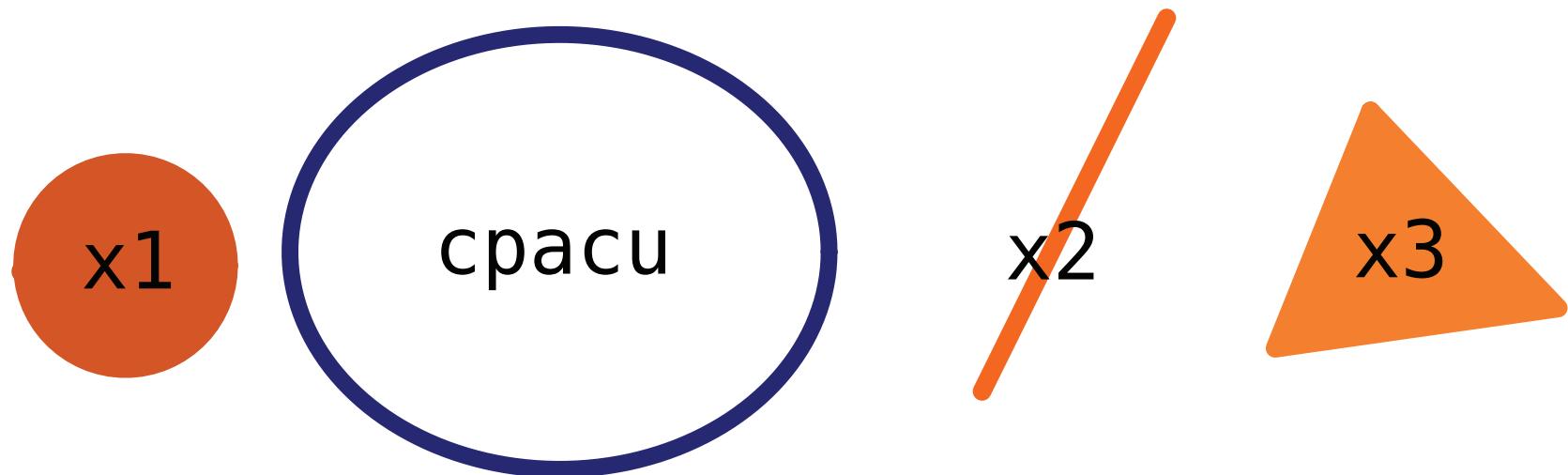


lojban (1987-) ver.1: 1997



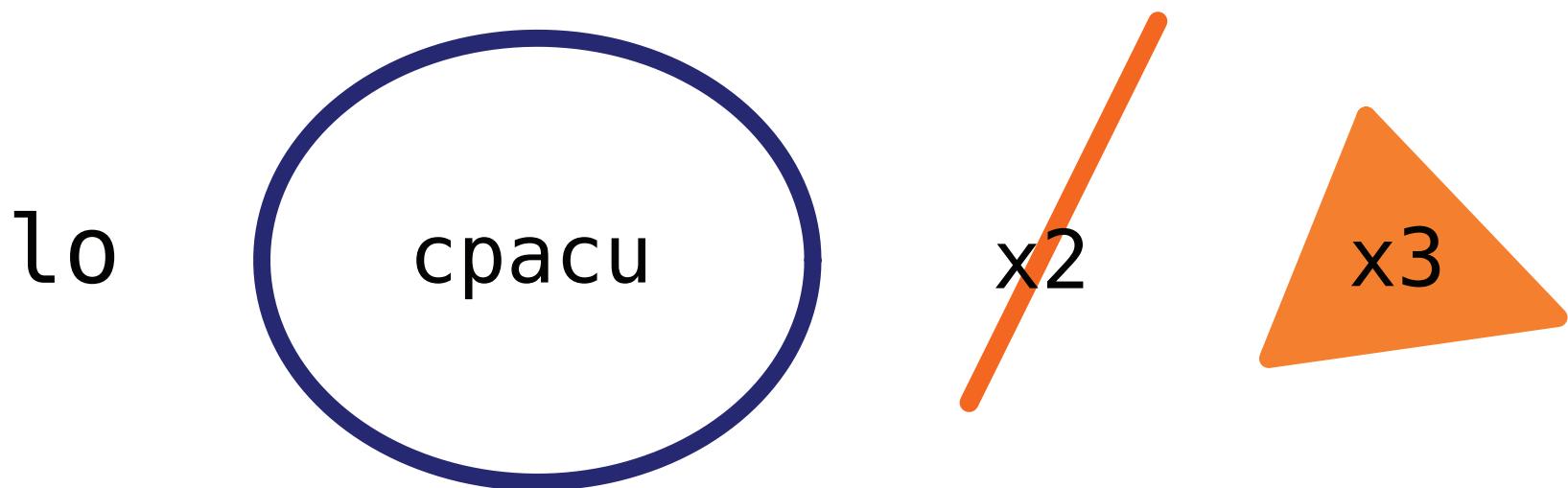
述語の1番めの項を抽出して、
description 描写 の形の項を作れる

lojban (1987-) ver.1: 1997



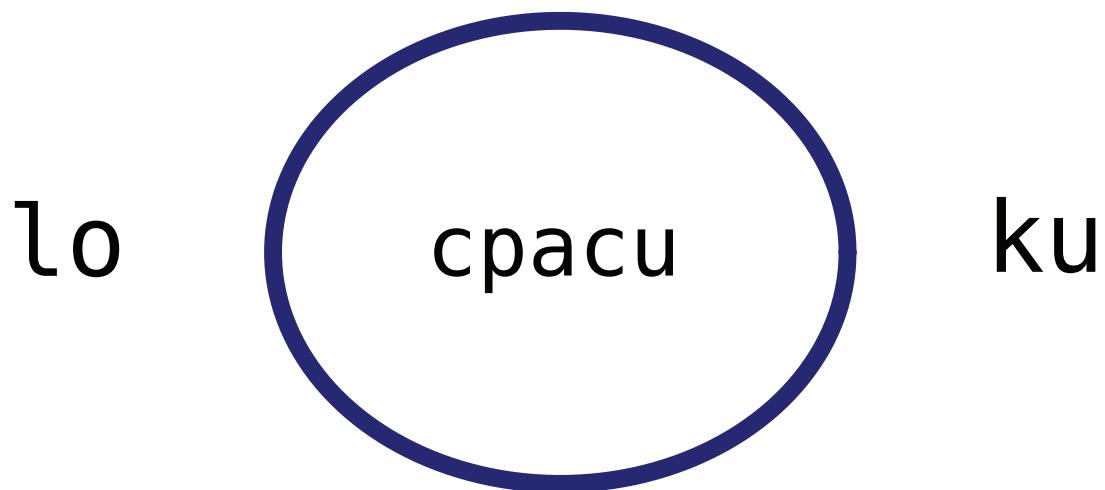
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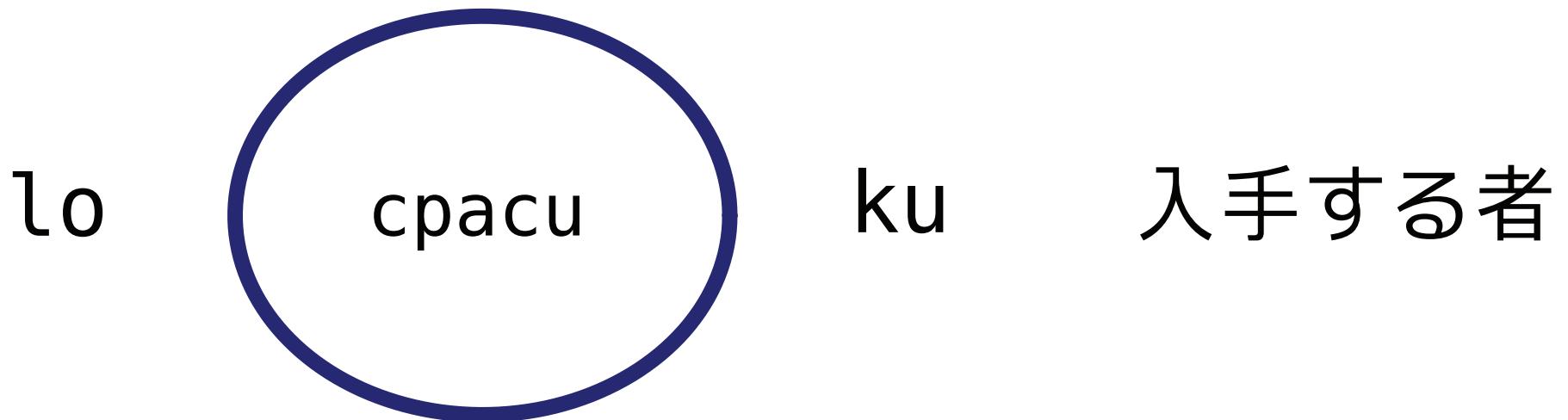
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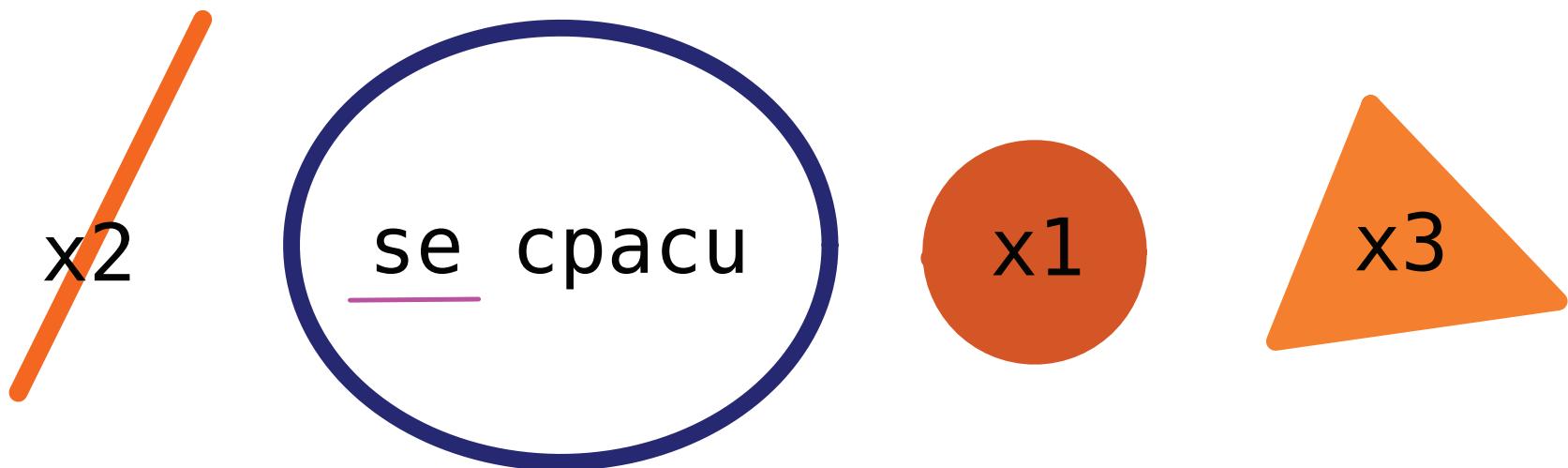
lojban (1987-) ver.1: 1997



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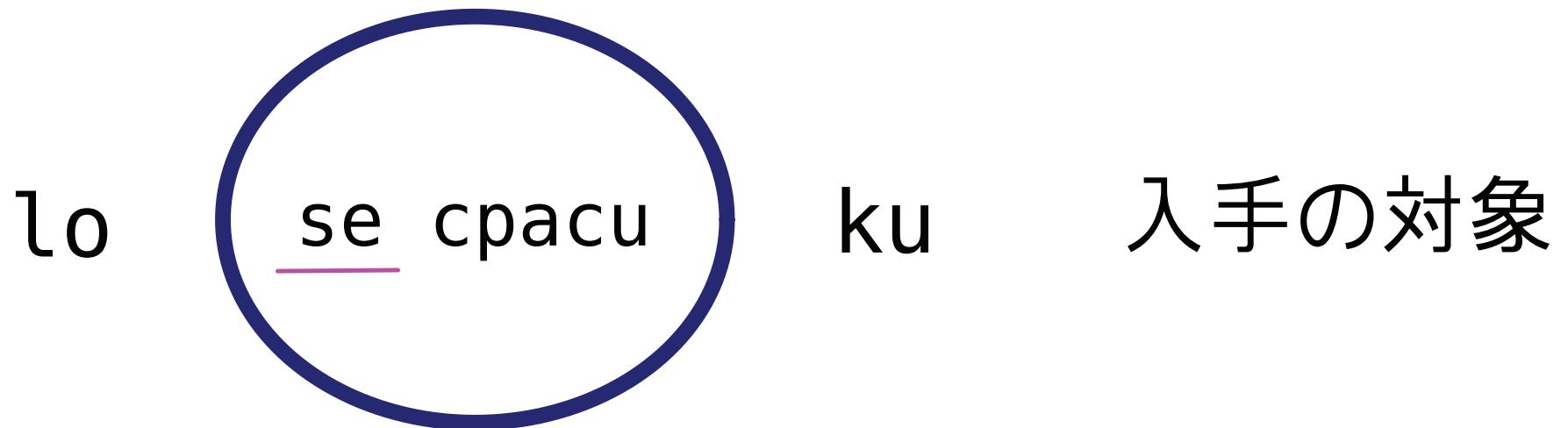
lojban (1987-) ver.1: 1997

項を入れ替える仕組み



lojban (1987-) ver.1: 1997

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lojban (1987-) ver.1: 1997

項を入れ替える仕組み

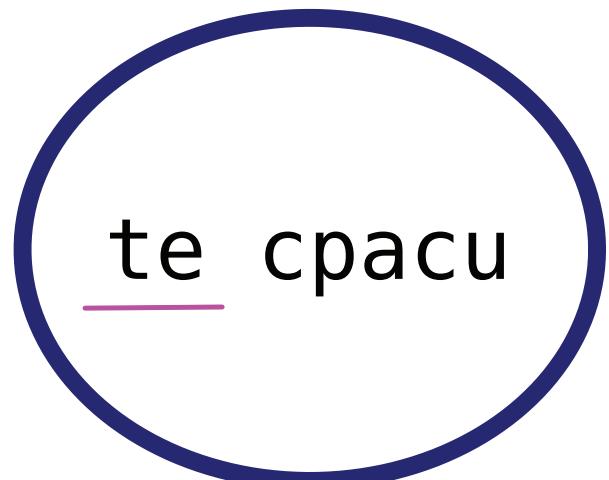
lo



ku

入手の対象

x3

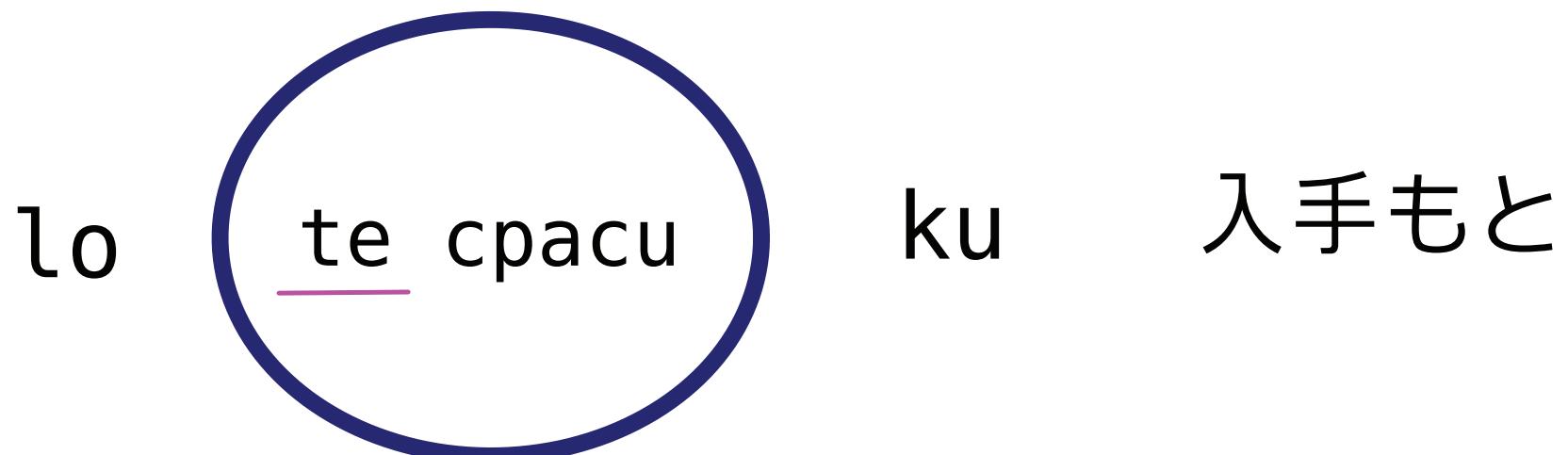


x2

x1

lojban (1987-) ver.1: 1997

項を入れ替える仕組み



lojban (1987-) ver.1: 1997

The Complete Lojban Language (1997):

lo cpacu ku

$\exists x \ C(x)$ となるx?



Bertrand Russell (1872-1970)

"On denoting" (1905)

The present King of France is bald.

lo ca fasygu'e nolraitru ku krecau

$\exists x?$

lojban (1987-)

Jorge Llambías (2004) : lo...kuの新解釈

lo cpacu ku

= zo'e noi ke'a cpacu

C(a) であるような自由変項a

lojban (1987-)

Jorge Llambías (2004) : lo...kuの新解釈

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= zo'e noi ke'a ca fasygu'e nolraitru ku krecau

= zo'e ge ca fasygu'e nolraitru gi krecau

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= zo'e ge ca fasygu'e nolraitru gi krecau
F(a) \wedge B(a)

lojban (1987-) 新解釈(2004)

zo'e ge ca fasygu'e nolraitru gi krecau

$$F(a) \wedge B(a)$$



Quine (1948):

To be is to be the value of a variable.

"On what there is"

lojban (1987-) 新解釈(2004)

zo'e ge ca fasygu'e nolraitru gi krecau

$$F(a) \wedge B(a)$$

su'o da zo'u

da ge ca fasygu'e nolraitru gi krecau

$$\exists x (F(x) \wedge B(x))$$



Quine (1948):

To be is to be the value of a variable.

"On what there is"

lojban (1987-) ver.1: 1997



Quine (1948):

"the thing that pegasizes"

"On what there is"

lojban (1987-) ver.1: 1997

la .pegasus. ペガススと呼ばれるもの（項）



Quine (1948):

"the thing that pegasizes"

"On what there is"

lojban (1987-) ver.1: 1997

la .pegasus. ペガススと呼ばれるもの（項）

me la .pegasus. ペガススる（述語）



Quine (1948):

"the thing that pegasizes"

"On what there is"

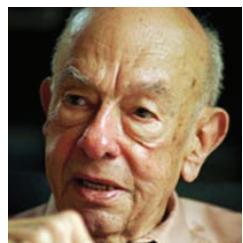
lojban (1987-) ver.1: 1997

la .pegasus. ペガススと呼ばれるもの（項）

me la .pegasus. ペガススる（述語）

su'o da zo'u da me la .pegasus.

$\exists x P(x)$

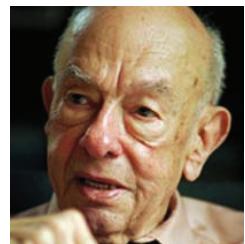


Quine (1948):

"the thing that pegasizes"

"On what there is"

lojban (1987-)



Quine (1948) :

"the thing that pegasizes"

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lojban (1987-)

Jorge Llambías (2007) : 新文法

.pegasus.

このまま述語として使える



Quine (1948) :

"the thing that pegasizes"

"On what there is"

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su'o da zo'u da .pegasus.

$\exists x P(x)$



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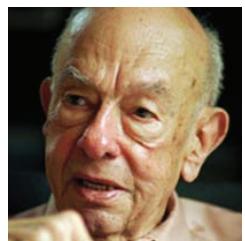
.pegasus. このまま述語として使える

su'o da zo'u da .pegasus.

$\exists x P(x)$

su'o da zo'u da krecau

$\exists x B(x)$

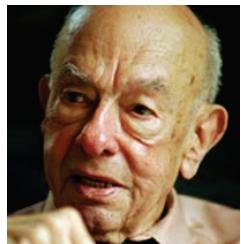


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lojban (1987-) ver.1: 1997



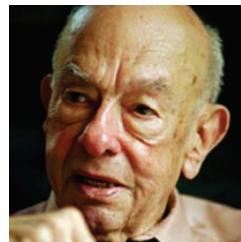
Quine:

use と mention を区別しよう

lojban (1987-) ver.1: 1997

la .pegasus.

ペガススと呼ばれるもの (use)



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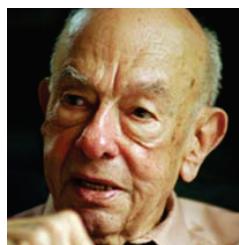
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lo du'u zo'e krecau

「某は禿だ」という命題」を指す自由変項



Quine:

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la .pegasus.	ペガススと呼ばれるもの (use)
zo .pegasus.	.pegasus. という記号 (mention)
zo'e krecau	「某は禿だ」という命題 (use)
lu zo'e krecau li'u	zo'e krecau という記号列 (mention)
lo du'u zo'e krecau	「某は禿だ」という命題」を指す自由変項
lo se du'u zo'e krecau	「某は禿だ」という命題を表す記号列を指す自由変項



Quine:

use と mention を区別しよう

lojbanと論理

lojbanと論理

lojban: 文法と意味論

lojbanと論理

lojban: 文法と意味論

論理: 公理と推論規則

lojbanと論理

lojban: 文法と意味論

論理: 公理と推論規則

lojbanで多様な論理を表現できる

lojbanと論理

Second-order logic

2階の述語論理

述語変数 bu'a, bu'e, bu'i

(bu'aの用例：

芥川龍之介『藪の中』ロジバン訳)

lojbanと論理

Third/higher-order logic
3階／高階の述語論理

lojbanと論理

Third/higher-order logic
3階／高階の述語論理

試験的な機能語を2個追加すれば可能

NU類 bu'ai
束縛述語変数を作る機能語

GOhA類 xe'u
NU類を冠頭に置くためのダミー的な機能語

lojbanと論理

multi-valued logic

多值論理

NAhE類では本当の多值論理を表せない

prenex (冠頭) に出せる term (名辞) になれるような
文法上の性質を持っていない

→ quantification (量化) と組み合わせて
公理や推論規則を定義することができない

lojbanと論理

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試験的な機能語の追加で対応できる

lojbanと論理

modal logic

様相論理

lojbanと論理

modal logic

様相論理

様相を表す単語 CAhA類

ca'a, ka'e, nu'o, pu'i

lojbanと論理

modal logic

様相論理

様相を表す単語 CAhA類

ca'a, ka'e, nu'o, pu'i

これに公理と推論規則を当てはめれば表現できる



Leibniz:

Sed ut redeam ad expressionem cogitationum per characteres, ita sentio nunquam controversias finiri neque sectis silentium imponi posse, nisi a ratiocinationibus complicatis ad calculos simplices, a vocabulis vagae incertaeque significationis ad characteres determinatos revocemur.

Id scilicet efficiendum est, ut omnis paralogismus nihil aliud sit quam error calculi, et ut sophisma, in hoc novae scripturae genere expressum, revera nihil aliud sit quam soloecismus vel barbarismus, ex ipsis grammatices hujus philosophicae legibus facile revincendus.

Quo facto, quando orientur controversiae, non magis disputatione opus erit inter duos philosophos, quam inter duos Computistas. Sufficiet enim calamos in manus sumere sedereque ad abacos, et sibi mutuo (accito si placet amico) dicere: calculemus.

"Vorarbeiten zur allgemeinen Charakteristik",
Die philosophischen Schriften (1890)

まとめ

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Ig Nobel 賞に値する

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lojban の意味論は
Quine の哲学に依るところが大きい

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Quine の哲学に依るところが大きい

lojban は Leibniz の
characteristica universalis の理想を
半分だけ実現している（との半分は無理）
→ 哲学的な推論をするのに適した言語