The Acquisition of the Count/Mass Distinction in Yudja (Tupi): Quantifying 'Quantity' and 'Number'

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1. Yudja: basic properties

Bare arguments Yudja is a bare noun language, i.e., nouns are unspecified for number (singular, plural) and unspecified for definiteness (definite or indefinite):

01 Ali ba'ï ixu
child paca eat
'A/the/some child(ren) eat(s)/ate the/a/some paca(s)'
lit: 'an undefined number of children eat(s)/ate an undefined number of pacas'

Plurals Yudja has an optional plural morpheme *-i* restricted to [+ human] nouns (Fargetti 2001). If a [+ human] noun refers to pluralities, the preference is to use the noun modified by *-i* (see 02b and 02c). However, a non-pluralized [+ human] noun can also refer to pluralities as we can see in (02a) below:

02a Senahï kota ixu
man snake eat
'A/the/some man/men eat(s)/ate a/the/some snake(s)'
lit: 'an undefined number of men eat(s)/ate an unspecified number of snakes'

02b Senahï-i kota ixu
man-PL snake eat
'(The/some) men eat/ate a/the/some snake(s)'
lit: 'a plural set of men eat/ate an unspecified number of snakes'

02c Kota senahï-i ixu
snake man- PL eat
'(A/the/some) snake(s) eat(s)/ate the/some men'
lit: an unspecified number of snakes eat(s)/ate a plural set of men'

02d * Kota-i senahï ixu
snake- PL man eat

02e * Senahï kota-i ixu
man snake-PL eat

Example (02a) is ambiguous between an interpretation where a single man or more than one man ate a/the snake(s). In (02b) and (02c), the plural morpheme *-i* excludes the possibility of the interpretation 'one single man'. (02d) and (02e) are ungrammatical because this morpheme is never associated with [- human] nouns. Also, the plural morpheme cannot be combined with nouns that denote substances, as illustrated below (03b and 04b):

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Yukïdï ‘salt’ (substance, non-liquid)

03a	Yauda	Maria	yukïdï	xaa	he	dju wï
	two	Maria	salt	bowl	in	bring
	‘Maria brought two bowls of salt’					

03b	*Yauda	Maria	yukïdï-i	xaa	he	dju wï
	two	Maria	salt- PL	bowl	in	bring

Awïla ‘honey’ (substance, liquid)

04a	Txabïu	awïla	xaa	he	txutxutxuka
	three	honey	bowl	in	bring.RED
	‘(Someone) brought three bowls of honey’				

04b	* Txabïu	awïla-i	xaa	he	txutxutxuka
	three	honey-PL	bowl	in	bring.RED

Quantifiers Yudja has a pair of quantifiers (*itxïbï* ‘many’/ *kïnana hinaku* ‘few’) that derive only count interpretations for all nouns:

iidja ‘woman’ (human)

5a	Itxïbï	iidja	5b	Kïnana hinaku	iidja
	many	woman		few	woman
	‘Many women’			‘Few women’	

y’a ‘water’ (substance)

6a	Itxïbï	y’a	6b	Kïnana hinaku	y’a
	many	water		few	water
	‘(There are) many containers of water’			‘(There are) few containers of water’	

Numerals Cross-linguistically, a measure/container phrase or classifier (like ‘pound’ as in *three pounds of sugar*) is required for a felicitous combination of a numerical expression with a mass noun. If a measure/container phrase or classifier is not available, a sentence that includes a numeral and a mass noun is either ungrammatical or requires reinterpretation of sorts (‘coercion’ or ‘type-shifting’):

English (Number-marking language)

7a	* Three meat(s)	7b	‘Three pounds of meat’

Mandarin (Classifier language; Chierchia 2010; 104 - example 5)

8a	* San	rou	8b	San	bang	rou
	three	meat		three	CL	meat
				‘Three pounds of meat’		

Dëne Suliné (Number-neutral language; Wilhelm 2008; 47 – examples 9 and 10)

9a	* Solághe	bër	9b	Solághe	nedádhi	bër
	five	meat		five	pound	meat
				‘Five pounds of meat’		

In Yudja, however, all nouns can be combined with numerals:

Ba’ï ‘paca’

10a	Txabïu	ba’ï	wãnã
	three	paca	ran
	‘Three pacas ran’		

Ali 'child'
10b Txabïu ali wãnã
three child ran
'Three children ran'

Pïkaha 'chair'
10c Txabïu Maria pïkaha ĩwã
three Maria chair buy.PL
'Maria bought three chairs'

Y'a 'water'
10d Maria yauda y'a dju wï
Maria two water bring
'Maria brought two containers of water'
lit: 'Maria brought two water'

Yukïdï 'salt'
10e Maria txabïu yukïdï apa
Maria three salt drop/fall
'Maria dropped three containers of salt'
lit.: 'Maria dropped three salt'

Apeta 'blood'
10f Txabïu uda apeta wï
three someone blood bring
'Someone brought three containers of blood'
lit.: 'Someone brought three blood(s)'

If nouns expected to be count (such as *baï'i,* paca) and nouns expected to be mass nouns (*apeta*, blood) can be equally combined with numerals, how do we define atoms for nouns that intuitively denote stuff? I suggest (based on Rothstein 2010) that nouns in Yudja include an atomic counting function relying on a contextual parameter in order to determine what counts as their minimal parts.

2. A contextual parameter for counting

We have seen that all nouns can be combined directly with numerals in Yudja, even substance-denoting nouns like apeta 'blood'. Following Kratzer (2007), we argue that nominal roots themselves denote kinds rather than sets of individuals. For a NP to denote a set of individuals, its nominal root must be combined with a silent functional head (c.f. Kratzer 2007)[1], which denotes a context sensitive atomic function. This function maps the kind denoted by the nominal root to a set of individuals. In different contexts, the function may map the same kind to different sets of individuals – i.e. what counts as an individual that instantiates a kind may vary across contexts (c.f. Rothstein 2010[2]). Formally, the proposal can be summarized as follows:
1. A nominal root N denotes a kind k.
2. An atomic function F, which is relative to a context c, maps k to a set of k-individuals (i.e. individuals that are instances of the kind). More precisely, given a context c, F maps k to a set of individuals x such that x is a part of the kind k and x is k-atom in a context c:

$[\![\text{F blood}]\!]^c = \lambda x.\ x \leq \text{BLOOD} \ \&\ \text{AT}(\text{BLOOD})(c)(x) = 1$
$\text{AT}(k)(c)(x) = 1$ iff x is k-atom in c

[1] For partially converging proposals cf. Borer (2005) and Chierchia (2010).
[2] For Rothstein (2010), count nouns are sets of pairs of an individual and a context k, in which the first member of the pair is an atom: $\text{COUNT}_k(N_{root}) = \{<d,k>: d \in N \cap k\}$ (Rothstein 2010; 264)

From this theoretical perspective, a NP can denote a set of individuals only if its root has been combined with a head denoting an atomic function F. The possibility of being count is not given a priori for any noun, but is always context dependent. This hypothesis predicts that there is no lexical distinction between count and mass nouns in the lexicon and that all nouns can be interpreted as count, context permitting. Two properties of Yudja can be used to motivate this hypothesis. First, all nouns can be combined directly with numerals without intervening classifiers or container/measure phrases (cf. examples 10d-10f)**.** Second, all nouns can be combined with quantifiers that only derive a count interpretation (cf. examples 5 and 6). Considering the predictions of the atomic function hypothesis, do Yudja speakers make a distinction between notional mass, notional count and aggregate nouns in quantity judgments tasks?

3. Quantity judgments in Yudja

3.1. Experimental studies on the count/mass distinction in Yudja

In two quantity judgment studies based on Barner and Snedeker (2005), I tested whether Yudja speakers make a distinction between notional mass nouns such as *y'a* 'water', aggregate nouns such as *abeata* 'clothes' and notional count nouns such as *karaxu* 'spoon'. Note that the participants for studies 1, 2 and 3 were the same and that studies 1, 2 and 3 were done in the same session. In this paper, the studies will be presented in the order they were presented to the participants. The atomic function hypothesis predicts that Yudja speakers will not vary their quantity judgments based on notional count, notional mass or aggregate nouns because there is no grammatical distinction between these types of nouns in Yudja. Therefore, if Yudja speakers do not base their quantity judgments on noun type (notional mass, notional count and aggregate nouns), the results will reinforce the atomic function hypothesis discussed in 2.

Study 1

Methods

Participants were 18 adults and 22 children (7, 2-to-5-year-olds; 15, 6-to-11-year-olds[3]). Children were divided in two groups according to schooling: 7- to-12-year-olds start to learn Brazilian Portuguese in the school while younger children are monolingual or are in a very early stage as Brazilian Portuguese learners. In this study, the participants saw two different drawings one with a big portion of *x* (Volume) and another with many different portions of *x* (Number). The target question was *Ma de bitu x dju au?* 'Who has more *x*?', as illustrated below[4]:

11a Notional mass nouns (*asa* 'flour', *y'a* 'water', *kania atxa* 'meat'):

Ma de bitu asa dju a'u?
who more flour have
'Who has more flour?'

[3] Number of children per age: 2, 2 year-olds; 1, 3 year-old; 1, 4-year-old; 3, 5-year-olds; 1, 6-year-old; 4, 7-year-olds; 3, 8-year-olds; 2, 9-year-olds; 2, 10-year-olds; 3, 11 year-olds.

[4] Independent evidence in Yudja shows that *bitu* 'more' can denote 'Number' and 'Volume' interpretations:

Bitu – 'Volume' interpretation Scenario: there are three boys and João is the tallest of them: 1a João bitu urahu hidji João more big, tall INTENS 'João is the tallest (lit.: more tall)	*Bitu* – 'Volume' interpretation Scenario: there are three girls and Maria is the smallest of them: 1b Maria bitu xĩ anu Maria more small ASP 'Maria is the smallest (lit: more small)'
Bitu – 'Number' interpretation Scenario: cooking instruction 2a Bitu puju itu yauda xaa wã'ẽ he more beans put two bowl pan in 'Put two more bowls of beans in the pan'	Bitu – 'Number' interpretation Scenario (spontaneous speech): a child wants to know if Suzi has more hair clips to give: 2b Suzi, au de bitu taba pïdïkaha Suzi have Q more hair clip 'Suzi, do you have more hair clips?'

11b Notional count nouns (*xaa* 'bowl', *txarina* 'chicken', *karaxu* 'spoon'):

Ma de bitu xaa dju a'u?
who more bowl have
'Who has more bowls?

11c Aggregate nouns (*abeata* 'clothes', *wã'e* 'ceramic'):

Ma de bitu abeata dju a'u?
who more clothes have
'Who has more clothes?'

As illustrated in 11a-11c, three notional classes of nouns (mass, aggregate and count nouns) were tested. Examples from each category are illustrated in 11a-11c. Similar to the critical items used by Barner and Snedeker 'the three objects had a smaller combined volume and surface area than the large object, allowing responses based on number to be distinguished from those based on mass or volume' (Barner and Snedeker 2005; 50). All items presented the same syntactic and morphological properties, as none of these nouns can be pluralized (only [+ human] nouns can be pluralized in Yudja, see Section 1).

Each participant answered 8 items in random order. Three items included notional count nouns (e.g. *xaa* 'bowl'), three items included notional mass nouns (e.g. *asa* 'flour') and two items included aggregate nouns (e.g. *abeata* 'clothes'). For all participants, the study took place in a room in the Yudja's local central school in the Tuba Tuba village. A local professor (native Yudja speaker) known by the children and their parents accompanied all the tasks that involved children. At the beginning of each study we explained that one person owned the big portion of *x* and another person owned the three small portions of *x*. The order of the presentation of the pictures (big portions vs. many portions) was counterbalanced and all participants saw the photos in the same order. All children were interviewed by the local indigenous professor (native speaker of Yudja). The same holds for studies 2 and 3. Participants had to point to one of the drawings to answer the target question ('who has more x?').

Results and discussion

The results for Study 1 are presented on Table 1. Yudja adults and 2- to-5-year-old children based their quantity judgments on 'Number' and 6-to-11-year-old based their quantity judgments on 'Volume':

Table 1. Results of study 1 – presented in percentage of 'Number' responses

Noun 'category'	Adults	Children (2-5)	Children (6-11)
Notional mass nouns	85%	57%	33%
Notional count nouns	83%	60%	33%
Aggregate nouns	79%	71%	43%

Adults favored the 'Number' answer for all nouns, which suggests a preference for count interpretation of nouns (including nouns that denote substances), when the context permits this interpretation. 2-to-5-year-old children performed at chance while 6-to-11-year-old children favored the 'Volume' answer for all nouns. The results presented in Table 1 show that all three groups of Yudja speakers do not differentiate noun types. That is, the same answer was consistently used across all noun (notional) types for the three groups of participants. Mixed effects modeling using Helmert contrasts confirmed that there was no effect of noun type. However, there was a significant effect of Age on proportion of number criterion responses (Wald's $Z = 2.5$, $p = 0.01$, $\beta = 0.122$). In Study 1 one factor with three levels ('count', 'mass' and 'aggregate') was manipulated in two Helmert contrasts. In

the first contrast notional count nouns were contrasted with aggregate nouns. It was observed that aggregate nouns have a greater probability of 'Number' responses in comparison to notional count nouns, but that is not significant (Wald's Z = 0.9, p = 0.35, β = 0.208). In the second contrast notional mass nouns were contrasted with aggregate and notional count nouns (that is, in the second contrast notional count and aggregate nouns were considered a single category). It was observed that notional count/aggregate nouns are numerically more likely to give 'Number' responses in comparison to notional mass, but that is not significant (Wald's Z = - 0.617, p = 0.53, β = - 0.070):

Table 2. Mixed effects modeling using Helmert contrasts – Results Study 1

	Estimate β (Standard error)	z value (Wald's Z)	Pr(>|z|)
Intercept	- 0.76421 (0.96600)	- 0.791	0.4289
Age	0.12246 (0.04801)	2.551	0.0107*
First contrast (notional count nouns vs. aggregate nouns)	0.20876 (0.22525)	0.927	0.3540
Second contrast (notional count nouns and aggregate nouns vs. notional mass nouns)	- 0.07007 (0.11363)	-0.617	0.5375

†: p < .1, *: p < .05, **: p < .01, ***: p < .001

Study 2

In quantity judgment studies in English, English speakers based their quantity judgments on 'Number' when they were presented to target sentences that included count and aggregate nouns and on 'Volume' when the target sentences included mass nouns (Barner and Snedeker (2005)). Barner and Snedeker (2005; 52) raised an issue concerning the experimental items in Study 1 for aggregate nouns (named in Barner and Snedeker as 'object-mass nouns' because in English they have the syntactic distribution of mass nouns, even though they refer to objects (cf. Schwarzschild 2007, Chierchia 2010). Because aggregate/object-mass nouns like *furniture* refer to a group of different objects, Barner and Snedeker (2005) discussed that the quantity comparison between one big chair vs. three small chairs may not be the best way to test the interpretation of aggregate/object-mass nouns because a single chair could not represent for the participants the concept of *furniture*. That is, Barner and Snedeker (2005) hypothesized that perhaps participants were reanalyzing *furniture* as *chair*. Therefore, in their second study the authors included multiple individuals for both 'Number' and 'Volume' answers. In our studies for Yudja the issue raised by Barner and Snedeker could also apply for nouns like *abeata* 'clothes' and *wa'ẽ* 'ceramics'. A second motivation for Study 2 in Yudja was to test whether the results from Study 1 for adults and 2-to-5-year-old children were just an effect of a strong preference for many portions of *x* over a single big portion of *x*.

Methods

Participants were the same 18 adults and 22 children (7, 2-to-5-year-olds; 15, 6-to-11-year-olds) that participated in Study 1. As in Study 1, Study 2 took place in one room of the local Yudja school in the Tuba Tuba village. A local professor known by the children and their parents accompanied all the tasks that involved children.

In this study, we asked the participants the same question that was asked in Study 1 (*Ma de bitu x dju a'u*? 'who has more *x*'?) and presented two different drawings: one with two big portions of *x* and another with many different portions of *x*, as illustrated below:

12a notional mass noun (*asa* 'flour')

Ma de bitu asa dju a'u?
Who more flour have
'Who has more flour?'

12b notional count noun (*xaa* 'bowl')

Ma de bitu xaa dju a'u?
who more bowl have
'Who has more bowls?'

12c aggregate noun (*abeata* 'clothes')

Ma de bitu abeata dju a'u?
who more clothes have
'Who has more clothes?'

As illustrated in 2a-2c, three notional classes of nouns (mass, aggregate and count nouns) were tested. As in Study 1, all items presented the same syntactic and morphological properties.

Each participant answered 3 items in random order: one item that included a notional count noun (*xaa* 'bowl'), one item that included a notional mass noun (*asa* 'flour') and one item that included an aggregate noun (*abeata* 'clothes'). At the beginning of each study we explained that one person owned two big portions of x and another person owned the six small portions of x. Participants had to point to one of the drawings to answers the target question (*Ma de bitu x dju a'u?* 'who has more x?').

Results and discussion

The results for Study 2 are presented on Table 3. All three groups tested kept the pattern observed in Study 1:

Table 3. Results of study 2 – presented in percentage of 'Number' responses

Noun 'category'	Adults	Children (2-5)	Children (6-11)
Notional mass nouns	64%	57%	26%
Notional count nouns	76%	57%	20%
Aggregate nouns	76%	71%	26%

Adults favored the 'Number' answer for all nouns. 2-to-5-year-old children performed at chance level while 6-to-11-year-old children favored the 'Volume' answer for all nouns. As in Study 1, we did not find a significant noun type effect. Instead, mixed effects modeling using Age as a predictor confirmed that there was a significant effect of Age on proportion of number criterion responses (Wald's Z = 2.2; p = 0.02; $\beta = 0.11$):

Table 4. Mixed effects modeling using Age as a predictor – Results Study 2

	Estimate β (Standard error)	z value (Wald's Z)	Pr(>|z|)
Intercept	- 1.96037 (1.17413)	- 1.670	0.0950
Age	0.12643 (0.05525)	2.288	0.0221 *

†: p < .1, *: p < .05, **: p < .01, ***: p < .001

Note that in the analysis for Study 2 we do not have noun contrasts in the model. We did not use Helmert contrasts because there was not enough data to fit the full model (given that each participant answered one question that included a notional count noun, one question that included a notional mass noun and one question that included an aggregate noun), and for that reason we removed the contrasts for noun type.

Study 3

In principle, Studies 1 and 2 may suggest an absence of a conceptual distinction between 'Volume' and 'Number'. In Study 3, I tested whether Yudja speakers make a distinction between 'Volume' and 'Number' when the target question enforces one of these interpretations.

Methods

Participants were the same 18 adults and 22 children (7, 2-to-5-year-olds; 15, 6-to-11-year-olds). In this study, the participants saw the drawings presented in Study 1 and answered two different questions:

13a 'Number' question (Quantifier)
Ma de itxïbï x dju a'u?
who many x have
Who has many portions of x?

NB: *itxïbï y'a* ('many containers of water')
itxïbï ba'ï ('many pacas')

13b 'Volume' question (Adjective)
Ma de urahu x dju a'u?
who big x have?
'Who has a big portion of x?

NB: *urahu y'a* ('a big puddle of water')
urahu ba'ï ('a big paca')

Results

The results for Study 3 are presented on Tables 3 and 4. All participants associated *urahu* to 'Volume' (Table 3) and *itxïbï* to 'Number' (Table 4). Thus, they conceptually distinguish 'Volume' from 'Number':

Table 5. Results for study 3 'urahu' – presented in percentage of 'Number' responses

'Noun category'	Adults	Children (2 - 5)	Children (6 -11)
Notional mass noun	0 %	28 %	33 %
Notional count noun	0 %	25 %	16 %
Aggregate noun	0 %	14 %	33 %

Table 6. Results for study 3 'itxïbï' – presented in percentage of 'Number' responses

'Noun category'	Adults	Children (2 – 5)	Children (6 - 11)
Notional mass noun	100%	89 %	91 %
Notional count noun	100%	92 %	100 %
Aggregate noun	100%	85 %	93 %

4. General discussion

Studies 1 and 2 lead us to two important conclusions: first, the categories 'Volume' and 'Number' tested above might not be grammaticalized as a distinction between count and mass nouns in Yudja. Second, all nouns can be treated as count, supporting the context-dependent atomic function hypothesis. Note that despite the differences between the answers for each age group, none of the groups presented different answers for potentially different noun types (notional count, notional mass and aggregate).

This task in other languages returned different results. In English, count and mass nouns have different grammatical properties (Chierchia 1998a, 1998b, 2010). In quantity judgment tasks, English speakers (16 adults and 16 children aged 4;1 – 4;6) 'based their quantity judgments on the number of individuals significantly more for count and object-mass nouns compared to substance-mass nouns' (Barner and Snedeker 2005; 50-52). Similarly, Li, Barner and Huang (2008), in a quantity judgment study in Mandarin (56 adult native speakers), has found a significant difference across noun types: the

participants 'based their judgment almost exclusively on number for count nouns (99.1% of the time), even in absence of classifiers. In contrast, participants in the mass noun condition never quantified by number (0%)' (Li et al. 2008; 13). The results for English (a number marking language) and Mandarin (a classifier language) show that despite their different grammatical properties, both of these languages provide the same answers in quantity judgment tasks. In languages like English and Chinese, differently from Yudja, grammatical properties (quantifiers, distribution of plural morphology and measure phrases in English, and count-classifiers and mass-classifiers in Chinese (cf. Cheng and Sybesma 1998, Chierchia 1998a, 1998b and 2010) strongly enforce a differentiation across noun types, which is reflected in their quantity judgments. I claim that the Yudja results differ from the English and Chinese results because as long as context permits, any noun can be used as count in Yudja.

In Studies 1 and 2, it is still an open question why 6-to-11-year-old children show a very distinct pattern in comparison to the two other age groups. One could hypothesize that their result is an effect of Brazilian Portuguese learning or schooling as in Brazilian Portuguese there is a grammatical distinction between count and mass nouns. The problem with this hypothesis is that Brazilian Portuguese speakers do not base their quantity judgment on 'Volume' for all nouns as 6-to-11-year-old Yudja children do. Instead, Brazilian Portuguese speakers, in a control group with 10 Brazilian Portuguese adults, based their quantity judgments on 'Number' for count and aggregate nouns and on 'Volume' for mass nouns, like English and Mandarin speakers did. Therefore, it may not be the case that 6-to-11-year-old children are influenced by the Brazilian Portuguese grammar in order to answer these tasks. A conclusive explanation for the performance of 6-to-11-year-old children in quantity judgment studies remains, however, an open question that will be explored in follow-up studies.

5. Conclusions

In this paper, I discussed the absence of a lexical count/mass distinction in Yudja. I argued in favor of the atomic function hypothesis: following Kratzer (2007), nominal roots denote kinds rather than sets of individuals. For a NP to denote a set of individuals, its nominal root must be combined with a silent functional head (c.f. Kratzer 2007), which denotes a context sensitive atomic function – i.e. what counts as an individual that instantiates a kind may vary across contexts (c.f. Rothstein 2010). The support to this analysis comes from constructions with numerals, quantifiers and quantity judgments. First, in constructions with numerals all nouns can be combined directly with numerals without intervening classifiers or container phrases. Second, all nouns can be combined with quantifiers that derive count interpretations. Third, in quantity judgment studies Yudja speakers based their quantity judgments significantly on 'Number' for all nouns tested. Crucially, noun type (count, mass or aggregate) did not affect their quantity judgments in Yudja.

In sum, in favor of the atomic function hypothesis: (1) Yudja speakers did not present different quantity judgments for notional mass, notional count and aggregate nouns; (2) Yudja speakers present an overall preference for 'Number' across age. To conclude, Study 3 shows that Yudja speakers make a conceptual distinction between 'Volume' and 'Number'. Nevertheless, Studies 1 and 2 show that all nouns can be treated as count (given the significant probability of 'Number' responses for all nouns). Therefore, the distinction between 'Volume' and 'Number' might not be grammaticalized as a distinction between count and mass nouns.

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