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dros Ymchwil i Ddwyieithrwydd
for Research on Bilingualism

Using constraint grammar in the Bangor Autoglosser to disambiguate multilingual spoken text

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BANGOR

Background

The Centre

- ESRC Centre for Research in Bilingualism
- Established January 2007
- Five research themes
- Corpus-based research
- **bilingualism.bangor.ac.uk**

Bangor corpora

	Chats	*Hours*	*Words*	*Date*
Welsh-English (Siarad)	69	40	456k	2009
Welsh-Spanish (Patagonia)	32	20	161k	2011
Spanish-English (Miami)	31	20	126k	2011
	132	**80**	**743k**	

All available under the GPL.

The conversations

- Transcribed using the CLAN format
- **childes.psy.cmu.edu/clan**
- Standard orthography
  - Elisions spelled out for Welsh:
  - **mae'n fawr** (it's big) →**mae (y)n fawr**
- Gloss added
- Free translation in English added

Sample utterances

***SER:** dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 .
%snd:"deuchar1"_72848_73881
%gls: be.1S.PRES PRON.1S PRT hopeless with take.NONFIN picture
%eng: I'm hopeless at drawing
***MYF:** +< &=laugh . %snd:"deuchar1"_73196_73881
***SER:** dw@1 i@1 (y)n@1 tynnu@1 llun@1 i@1 [/] i@1 (y)r@1 plant@1 <i@1 plant@1> [//] <i@1 (y)r@1> [//] # i@1 er@0 &h Helen@0 a@1 Susanna@0 a@1 +/. %snd:"deuchar1"_73881_79477
%gls: be.1S.PRES PRON.1S PRT take.NONFIN picture for for DET children for children for DET for IM Helen and Susanna and
%eng: I draw a picture for . . . for the children, for, er, Helen and Susanna and . . .

(Siarad corpus, deuchar1)

Utterance format

*SER dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 . %snd:"deuchar1"_72848_73881

Speaker	*SER
Utterance	dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 .
Language tags	1=Welsh, 2=English, 0=undetermined
Audio location	%snd:"deuchar1"_72848_73881
Manual gloss	be.1S.PRES PRON.1S PRT hopeless with take.NONFIN picture

Why?

- Examine how language is actually used
- Differences between spoken language and formal written language
- Sociolinguistic variation – what is used where by whom
- Balance between languages in bilingual usage
- How one language handles lexical items from the other
  - Welsh loan-verbs such as *textio* (to text) behave more like ordinary Welsh verbs the more frequent they are

Glossing

Why gloss?

- Lexemes and part-of-speech (POS) tags:
  - Help non-native speakers parse the conversation
  - Allow further analysis - morphological, syntactic, sociolinguistic
- Difficulties:
  - Time-consuming and tedious
  - Inconsistency and errors (*ychydig* – "a_bit"/"a_little")
  - Tag choice difficult to revise later

Automation

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- April 2010
- Explore automation to address difficulties above
- Move towards more granular POS information
- Welsh →Spanish →English
- Accuracy reflects timespend:
  99% for Welsh, and 95% for English.
- Work in progress

Why another wheel?

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- CLAN tagging system
    - For 11 languages > 5m speakers
    - Requires one pass for each language
    - Can't mix language context
    - Vocabulary stored in a number of files
    - Disambiguation for only 4 languages
- Toolbox
- No automated system for small languages

Pilot project

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- Test project over two weeks:
  - No disambiguation
  - Write out entries from Spanish dictionary
  - **apertium.org**
  - Compare them with MOR output
  - Write out entries from Welsh dictionary
  - **eurfa.org.uk**
- Good results
- Needed a way to disambiguate - enter CG!

Dictionaries

Dictionaries

- Derived from GPL or PD resources
- One database table
- Words, not morphemes
- Easily presented in a spreadsheet
- Easy to update
- Easy to get started

Welsh dictionary

surface	*lemma*	*enlemma*	*pos*	*gender*	*number*	*tense*
bara	bara	bread	n	m	sg	
cathod	cath	cat	n	f	pl	
mynd	mynd	go	v			infin
aeth	mynd	go	v		3s	past
hapus	hapus	happy	adj			
rhywsut	rhywsut	somehow	adv			
heb	heb	without	prep			

Spanish dictionary

surface	*lemma*	*enlemma*	*pos*	*gender*	*number*	*tense*
perro	perro	dog	n	m	sg	
canciones	canción	song	n	f	pl	
empezar	empezar	start	v			infin
empieza	empezar	start	v		23s	pres
empieza	empezar	start	v		2s	imper
rojo	rojo	red	adj	m	sg	
rojas	rojo	red	adj	f	pl	
por	por	for	prep			

Language differences

- Spanish and Welsh
  - Inflected (Welsh less so than it was)
  - Surface forms give clues about the POS
- English
  - Analytic
  - Homophonous surface forms
  - POS defined by role in the sentence
  - **break**
    - *a clean break* (noun)
    - *break the mould!* (imperative)
    - *to break a habit* (infinitive)
    - *they break everything* (present)

English dictionary

surface	*lemma*	*pos*	*number*	*tense*
break	break	sv		infin
broke	break	av		past
broken	break	av		pastpart
car	car	n	sg	
quick	adj			
by	by	prep		
which	which	rel		

breaks, breaking, cars, quickly are derived during lookup

Import: Dictionary lookup and segmentation

Import the chat file

- PHP script reads each line into a PostgreSQL database table
- Selects the utterance and discards markers
- Splits the cleaned utterance into words
- Puts them into another database table

Utterance format

**SER dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 . %snd:"deuchar1"_72848_73881*

Speaker	*SER
Utterance	dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 .
Language tags	1=Welsh, 2=English, 0=undetermined
Audio location	%snd:"deuchar1"_72848_73881
Manual gloss	be.1S.PRES PRON.1S PRT hopeless with take.NONFIN picture

Utterance-table fields

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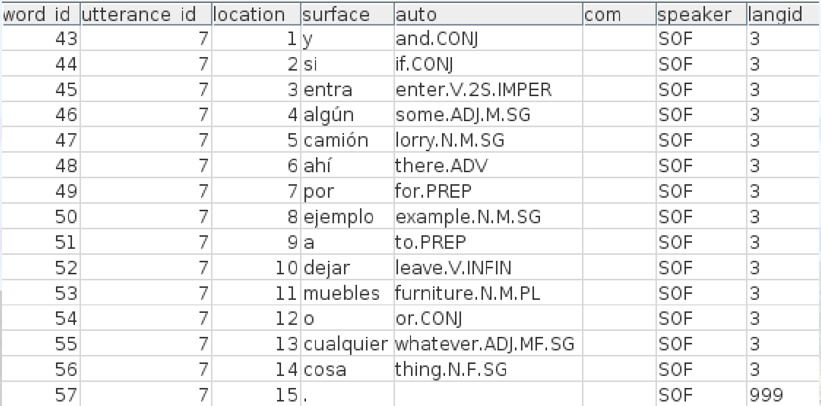
- utterance_id
- filename
- speaker
- surface
- startpoint
- endpoint
- duration
- manual glosses (if present)
- English translation (if present)
- comments (if present)
- precode (if present – marks entire utterances in the least-frequent language)

Word-table fields

- word_id
- utterance_id
- location of the word in the utterance
- surface
- automatic glosses
- manual glosses (if present)
- language id
- speaker
- filename

The words table



word_id	utterance_id	location	surface	auto	com	speaker	langid
43	7	1	y	and.CONJ		SOF	3
44	7	2	si	if.CONJ		SOF	3
45	7	3	entra	enter.V.2S.IMPER		SOF	3
46	7	4	algún	some.ADJ.M.SG		SOF	3
47	7	5	camión	lorry.N.M.SG		SOF	3
48	7	6	ahí	there.ADV		SOF	3
49	7	7	por	for.PREP		SOF	3
50	7	8	ejemplo	example.N.M.SG		SOF	3
51	7	9	a	to.PREP		SOF	3
52	7	10	dejar	leave.V.INFIN		SOF	3
53	7	11	muebles	furniture.N.M.PL		SOF	3
54	7	12	o	or.CONJ		SOF	3
55	7	13	cualquier	whatever.ADJ.MF.SG		SOF	3
56	7	14	cosa	thing.N.F.SG		SOF	3
57	7	15	.			SOF	999

Lookup

- Each word is looked up against the appropriate dictionary
- Uses the language id assigned to the word
- Writes out all “hits” in the CG input format

Segmentation

- Lookup also does some basic segmentation
- Minimises number of dictionary entries (**break** above)
- Welsh: mutated words are tagged
  - thad →tad (*father*) + am
  - gael →cael (*get*) + am
- Spanish: clitic pronouns are tagged
  - ponerle →poner (*put*) + le[pron.mf.3s]
  - déjanos →dejar (*leave*)+ nos[pron.mf.1p]

Mutation

- **tad** (father)
  - **ei dad** (his father)
  - **ei thad** (her father)
- **marw** (die, dead)
  - **mae o'n marw** (he is dying)
  - **mae o'n farw** (he is dead)
- direct object following a verb
  - **Mi werthodd y ffermwr y mochyn** (The farmer sold the pig)
  - **Mi werthodd y ffermwr fochyn** (The farmer sold a pig)

Welsh before CG

```
"<ddim>"
    "dim"  {96,1} [cy] n m sg :nothing: [208789] + sm
    "dim"  {96,1} [cy] adv :not: [204176] + sm
"<yn>"
    "yn"  {96,2} [cy] stat :stative: [200654]
    "yn"  {96,2} [cy] prep :in: [204430]
    "gan"  {96,2} [cy] prep :with: [196964] + sm
"<gynnar>"
    "cynnar"  {96,3} [cy] adj :early: [209212] + sm
"<iawn>"
    "iawn"  {96,4} [cy] adv :OK: [207540]
    "iawn"  {96,4} [cy] adv :very: [203775]
```

(Patagonia corpus, patagonia1)

"not very early"

Welsh after CG

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```
"<ddim>"
    "dim" {96,1} [cy] adv :not: [204176] + sm
"<yn>"
    "yn" {96,2} [cy] stat :stative: [200654]
"<gynnar>"
    "cynnar" {96,3} [cy] adj :early: [209212] + sm
"<iawn>"
    "iawn" {96,4} [cy] adv :very: [203775]
```

(Patagonia corpus, patagonia1)

"*not very early*"

Spanish before CG

```
"<vamos>"
    "ir"  {122,3} [es] v 1p pres :go: [115789]
"<a>"
    "a"  {122,4} [es] prep :to: [1]
"<hacerle>"
    "hacer"  {122,5} [es] v infin :do: [62577] + le[pron.mf.3s]
"<el>"
    "el"  {122,6} [es] det.def m sg :the: [45129]
"<baño>"
    "baño"  {122,7} [es] n m sg :bathroom: [16011]
    "bañar"  {122,7} [es] v 1s pres :bathe: [16010]
```

(Patagonia corpus, patagonia1)

"*we're going to do the bathroom*"

Spanish after CG

```
"<vamos>"
    "ir" {122,3} [es] v 1p pres :go: [115789]
"<a>"
    "a" {122,4} [es] prep :to: [1]
"<hacerle>"
    "hacer" {122,5} [es] v infin :do: [62577] + le[pron.mf.3s]
"<el>"
    "el" {122,6} [es] det.def m sg :the: [45129]
"<baño>"
    "baño" {122,7} [es] n m sg :bathroom: [16011]
```

(Miami corpus, sastre1)

“*we’re going to do the bathroom*”

English Segmentation

- Elisions are tagged
  - gonna →go # to.prep
  - we're →we # be.v.pres
- Plurals or verbs (3p sg pres) are tagged
  - breaks →break # pv
- Adjectives or verbs (past or pastpart) are tagged
  - constructed →construct # av
- Adjectives, singular nouns or verbs (prespart) are tagged
  - thinking →think # asv

English before CG

```
"<it’s>"
    "it"  {545,1} [en] pron.sub 3s :it: [130342] # gb
"<coming>"
    "come"  {545,2} [en] sv infin :come: [82193] # asv
"<out>"
    "out"  {545,3} [en] adv :out: [157287]
"<on>"
    "on"  {545,4} [en] prep :on: [156077]
"<D_V_D>"
    "D_V_D"  {545,5} [en] name
"<then>"
    "then"  {545,6} [en] adv :then: [208154]
```

(Miami corpus, herring7)

English after CG

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```
"<it’s>"
    "it" {545,1} [en] pron.sub 3s :it: [130342] # be.v.3s.pres
"<coming>"
    "come" {545,2} [en] v prespart :come: [82193] #
"<out>"
    "out" {545,3} [en] adv :out: [157287]
"<on>"
    "on" {545,4} [en] prep :on: [156077]
"<D_V_D>"
    "D_V_D" {545,5} [en] name
"<then>"
    "then" {545,6} [en] adv :then: [208154]
```

(Miami corpus, herring7)

Multilingual disambiguation

Multiple languages

- Ensure that each “hit” in the input file is tagged for language
- Put all the rules into one grammar file, grouped according to language
- Constrain the rules to act only on one language by including that language’s tag in the rule

Sample rule

- select (n) if (-1 (ord));
- choose the noun reading if the preceding word is an ordinal
- select ([es] n) if (-1 ([es] ord));
- applies only to Spanish (**el primer viaje**)

Welsh/Spanish

```
"<mewn>"
    "mewn" {128,4} [cy] prep :in:
"<motor>"
    "motor" {128,5} [es] n m sg :motor:
"<newydd>"
    "newydd" {128,6} [cy] adj :new:
"<internacional>"
    "internacional" {128,7} [es] adj m sg :international:
```

(Patagonia corpus, patagonia2)

"in a new international motor-car"

Spanish/English

```
"<con>"
    "con" {60,1} [es] prep :with: [132994]
"<el>"
    "el" {60,2} [es] det.def m sg :the: [45129]
"<address>"
    "address" {60,3} [en] n sg :address: [55976]
"<de>"
    "de" {60,4} [es] prep :of: [33387]
"<aquí>"
    "aquí" {60,5} [es] adv :here: [11385]
```

(Miami corpus, zeledon5)

"*with the address from here*"

Welsh/English

```
"<ac>"
    "ac" {27,1} [cy] conj :and: [209088]
"<oedd>"
    "bod" {27,2} [cy] v 3s imperf :be: [74724]
"<o>"
    "fo" {27,3} [cy] pron m 3s spoken :he: [209264]
"<gynno>"
    "gan" {27,4} [cy] prep+pron m 3s :with_him: [207424]
"<fo>"
    "fo" {27,5} [cy] pron m 3s :he: [196922]
"<background>"
    "background" {27,6} [en] n sg :background: [64983]
"<ddu>"
    "du" {27,7} [cy] adj :black: [209631] + sm
```

(Siarad corpus, deuchar1)

“and it was . . . it had a black background”

Cross-boundary rules

- Rules can apply across language boundaries
- Remove the language constraint when appropriate

Spanish adjective

```
"<es>"
    "ser"  {500,1} [es] v 23s pres :be: [51318]
"<otro>"
    "otro"  {500,2} [es] adj m sg :other: [83612]
    "otro"  {500,2} [es] pron m sg :other: [83613]
"<zip>"
    "zip"  {500,3} [en] n sg :zip: [1758]
"<code>"
    "code"  {500,4} [en] n sg :code: [81254]
```

(Miami corpus, sastre1)

"*it's another zipcode*"

Spanish adjective rule

- **otro** can be an adjective before a noun, or a pronoun
- The selection rule leaves the noun unspecified as to language:
- select ([es] adj) if (1 (n));
- *adjective* will be selected before **any** *noun* (not just Spanish)

Spanish adjective output

```
"<es>"
"ser" {500,1} [es] v 23s pres :be: [51318]
"<otro>"
"otro" {500,2} [es] adj m sg :other: [83612]
"<zip>"
"zip" {500,3} [en] n sg :zip: [1758]
"<code>"
"code" {500,4} [en] n sg :code: [81254]
```

(Miami corpus, sastre1)

“*it’s another zipcode*”

English verb

```
"<cada>"
    "cada"  {79,5} [es] adj mf sg :every: [18541]
"<vez>"
    "vez"  {79,6} [es] n f sg :time: [116758]
"<que>"
    "que"  {79,7} [es] conj :than: [93349]
    "que"  {79,7} [es] conj :that: [93350]
"<nos>"
    "yo"  {79,8} [es] pron.obl mf 1p :us: [80717]
"<vamos>"
    "ir"  {79,9} [es] v 1p pres :go: [115789]
"<camping>"
    "camp"  {79,10} [en] sv infin :camp: [74449] # asv
```

(Miami corpus, sastre1)

"every time that we go camping"

English verb rule

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- **camping** can be an adjective, a singular noun, or a verb
- *be thinking, enjoy reading, go fishing*
- In **vamos camping**, we can get the correct end tag by specifying the meaning of the preceding verb, rather than the lemma:
- substitute (sv infin asv) (v prespart) ([en] sv infin asv) (-1 ([en] "be") or (:go:));
- The tags on **camping** are rewritten to tag it as a present participle

English verb output

```
"<cada>"
    "cada" {79,5} [es] adj mf sg :every: [18541]
"<vez>"
    "vez" {79,6} [es] n f sg :time: [116758]
"<que>"
    "que" {79,7} [es] pron.rel :that: [93350]
"<nos>"
    "yo" {79,8} [es] pron.obl mf 1p :us: [80717]
"<vamos>"
    "ir" {79,9} [es] v 1p pres :go: [115789]
"<camping>"
    "camp" {79,10} [en] v prespart :camp: [74449] #
```

(Miami corpus, sastre1)

"*every time that we go camping*"

Rule types and language type

Removal

- “Delete” items from the dictionary
- Homonym selection
- select (”cyfeiriad” [cy] :direction:);
- Archaic/infrequent words
- remove (”tasu” [cy] :stack:);

Compensate

- Remove words which are an artefact of the lookup
- remove ([cy] ”mynd” v 2s imper nm);
- *nos* $<$ *dos*
- remove ([in] ”gum” n sg sm);
- *um* $<$ *gum*

English

- substitute (n sg pv) (n pl) ([en] n sg pv);
- *house* → *houses*
- substitute (as) (adj) ([en] as) (1 ([en] n) or ([en] pron));
- *a miniature rabbit, miniature ones*

English

- substitute (pron.sub) (pron.obj) ([en] pron.sub) (-1 ([en] v infin));
- *and open it*
- substitute (sv infin av) (v past) ([en] sv infin av) (-2 ([en] pron.sub)) (-1 preverbal);
- *they closed*

English

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- substitute (av past) (v past) ([en] av past) (-1 ([en] pron.sub)) (not -1 (have.v.pres)) (not -2 ("have"));
- *we bought*, **not** *you've done, we have bought*
- substitute (av past) (v pastpart) ([en] av past) (-1 (have.v.pres) or ("have") or ("be") or (det.def) or (det.indef));
- *you've done, you have done, it was misspent, un rebuilt*

English

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- Refine existing tags
- substitute (123p) (1p) ([en] v 123p) (-1 (pron.sub 1p));
- *we are*
- In general, more dependent on rule order

Default choices

- When left with an [or], we can make a “default“ choice
- select ([cy] v infin) if (0C ([cy] v infin) or ([cy] v 3s imper));
- *cerdded*
- C enforces the two conditions

Careful . . .

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- Scope of **remove** can be unexpected
- Likewise **select-if-not**
- select (imper) if (not @1 ("ni"));
- Caused 304 regressions in Spanish output!

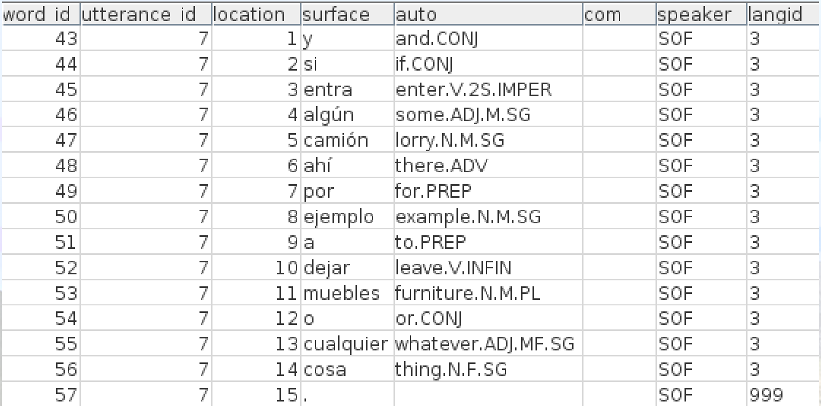
Rule numbers

- Spanish: 150
- Welsh: 180
- English: 200

Output method

- CG writes out the disambiguated text
- This file is parsed
- The glosses (lexeme + POS tag) are inserted into the words table
- The words are then written out to create the autoglossed file

The words table



word id	utterance id	location	surface	auto	com	speaker	langid
43	7	1	y	and.CONJ		SOF	3
44	7	2	si	if.CONJ		SOF	3
45	7	3	entra	enter.V.2S.IMPER		SOF	3
46	7	4	algún	some.ADJ.M.SG		SOF	3
47	7	5	camión	lorry.N.M.SG		SOF	3
48	7	6	ahí	there.ADV		SOF	3
49	7	7	por	for.PREP		SOF	3
50	7	8	ejemplo	example.N.M.SG		SOF	3
51	7	9	a	to.PREP		SOF	3
52	7	10	dejar	leave.V.INFIN		SOF	3
53	7	11	muebles	furniture.N.M.PL		SOF	3
54	7	12	o	or.CONJ		SOF	3
55	7	13	cualquier	whatever.ADJ.MF.SG		SOF	3
56	7	14	cosa	thing.N.F.SG		SOF	3
57	7	15	.			SOF	999

Accuracy

Accuracy

	Words	*Coverage*	*MFL*	*Accuracy*
Welsh-Spanish (Patagonia[1])	15,677	100%	W:92%	99%
Spanish-English (Miami[2])	4,202	97%	S:59%	97%
Welsh-English (Siarad[3])	10,411	96%	W:81%	98%

[1] patagonia1,2,3,6

[2] zeledon5

[3] stammers4, deuchar1

Dictionary coverage

	Words	*Nouns*	
Welsh	209k	6k	3%
Spanish	130k	19k	15%

Speed

- 900-1100 words per minute
- 1 minute to autogloss 5 minutes of manually-glossed speech
- Siarad: 500,000 words in 8h27m

Sample utterances

***SER:** dw@1 i@1 (y)n@1 hopeless@2 efo@1 tynnu@1 llun@1 . %snd:”deuchar1”_72848_73881

%gls: be.1S.PRES PRON.1S PRT hopeless with take.NONFIN picture

%eng: I’m hopeless at drawing

***MYF:** +< &=laugh . %snd:”deuchar1”_73196_73881

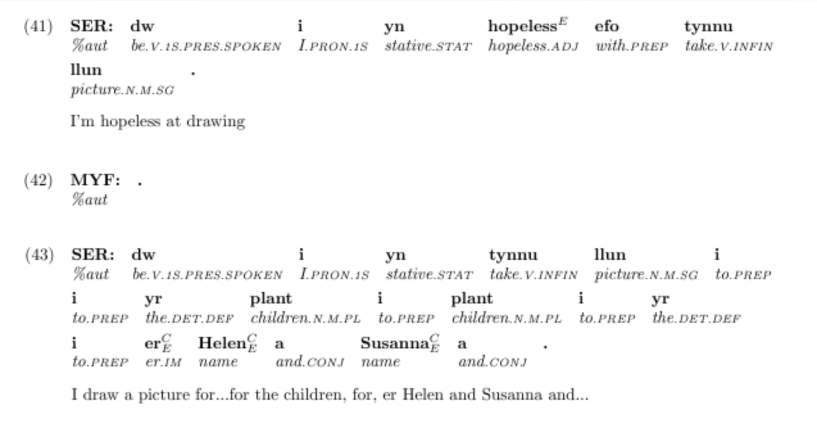
***SER:** dw@1 i@1 (y)n@1 tynnu@1 llun@1 i@1 [/] i@1 (y)r@1 plant@1 <i@1 plant@1> [//] <i@1 (y)r@1> [//] # i@1 er@0 &h Helen@0 a@1 Susanna@0 a@1 +/. %snd:”deuchar1”_73881_79477

%gls: be.1S.PRES PRON.1S PRT take.NONFIN picture for for DET children for children for DET for IM Helen and Susanna and

%eng: I draw a picture for . . . for the children, for, er, Helen and Susanna and . . .

(Siarad corpus, deuchar1)

Typesetting



(41)	**SER:**	**dw**	**i**	**yn**	**hopeless**^{E}	**efo**	**tynnu**
	%aut	*be.*V.1S.PRES.SPOKEN	*I.*PRON.1S	*stative.*STAT	*hopeless.*ADJ	*with.*PREP	*take.*V.INFIN
	llun	**.**					
	*picture.*N.M.SG						

I'm hopeless at drawing

(42)	**MYF:**	**.**
	%aut	

(43)	**SER:**	**dw**	**i**	**yn**	**tynnu**	**llun**	**i**
	%aut	*be.*V.1S.PRES.SPOKEN	*I.*PRON.1S	*stative.*STAT	*take.*V.INFIN	*picture.*N.M.SG	*to.*PREP
	i	**yr**	**plant**	**i**	**plant**	**i**	**yr**
	*to.*PREP	*the.*DET.DEF	*children.*N.M.PL	*to.*PREP	*children.*N.M.PL	*to.*PREP	*the.*DET.DEF
	i	**er**$^{C}_{E}$	**Helen**$^{C}_{E}$	**a**	**Susanna**$^{C}_{E}$	**a**	**.**
	*to.*PREP	*er.*IM	*name*	*and.*CONJ	*name*	*and.*CONJ	

I draw a picture for...for the children, for, er Helen and Susanna and...

Texts

- Check on typos – proof-reading
- Consistent glosses
- More granular analysis
- Global tag changes or enrichment

Data-mining

- Interactive webpages (*bangortalk.org.uk*)
- Easier or more detailed statistical analysis with R
- Input to machine translation. speech-to-text, etc

thinkopen.org.uk/git