VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

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2014-27815-116181-10	2014-4788

2014
Project Research Grant

Area of science
Natural and Engineering Sciences

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Total amount for which applied (kSEK)

2015	2016	2017	2018	2019
994	1002	1081	1149	1253

APPLICANT

Name(Last name, First name)
Ljunglöf, Peter

Date of birth
711031-2910

Gender
Male

Email address
peter.ljunglof@gu.se

Academic title
Associate professor

Position
Biträdande lektor

Phone
0736-242476

Doctoral degree awarded (yyyy-mm-dd)
2004-12-07

WORKING ADDRESS

University/corresponding, Department, Section/Unit, Address, etc.
Göteborgs universitet
Dept. of Computer Science and Engineering
Computer Science and Engineering
Rännvägen 6b
41296 Göteborg,

ADMINISTRATING ORGANISATION

Administrating Organisation
Göteborgs universitet

DESCRIPTIVE DATA

Project title, Swedish (max 200 char)
MUSTE: Multimodal semantisk textredigering

Project title, English (max 200 char)
MUSTE: Multimodal semantic text editing

Abstract (max 1500 char)

Over the last 10-20 years several different modes of human computer interaction have emerged, such as speech recognition, touch screens and eye tracking. During the same time the amount of text interactions has increase enormously over the years -- e.g., over 50 billion text messages are sent every day, only counting SMS and chat clients. But the full potential of the new modalities remains largely unexploited -- text authoring is viewed conceptually as an incremental left-to-right process, where a text is authored by adding new words at the end. This view has some problems, especially when it comes to new modalities such as touch screens:

- A virtual touch-screen keyboard is cognitively demanding, since the user cannot get haptic feedback but instead have to constantly look at the virtual keys.

- Letter-by-letter text authoring is by itself demanding for cognitively disabled users, since it requires so many interactions with the device.

- The incremental view focuses on how to enter new text, and does not give much help when it comes to editing existing text.

The basic problem that we want to solve in this project is how to reduce the cognitive load when authoring and editing text on devices with non-traditional input modalities. Our approach is that the user should be able to modify any word or phrase in the text at any time, and the system should be helpful and suggest good alternative formulations.

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Name of Applicant
Ljunglöf, Peter

Date of birth
711031-2910

Abstract language
English

Keywords
text editing, computational linguistics, user interface

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Project also includes other research area

Classification codes (SCB) in order of priority
10208, 10204,

Aspects
Ethical considerations are described in enclosed appendix A on page: 9

Continuation grant
Application concerns: New grant
Registration Number:

Application is also submitted to

similar to: **identical to:**

ANIMAL STUDIES

Animal studies
No animal experiments

OTHER CO-WORKER

Name(Last name, First name)	**University/corresponding, Department, Section/Unit, Addressetc.**
,	
Date of birth	**Gender**
Academic title	**Doctoral degree awarded (yyyy-mm-dd)**

Name(Last name, First name)	**University/corresponding, Department, Section/Unit, Addressetc.**
,	
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Name(Last name, First name)	**University/corresponding, Department, Section/Unit, Addressetc.**
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ENCLOSED APPENDICES

A, B, C, N, S

APPLIED FUNDING: THIS APPLICATION

Funding period (planned start and end date)

2015-01-01 -- 2019-12-31

Staff/ salaries (kSEK)

Main applicant	**% of full time in the project**	**2015**	**2016**	**2017**	**2018**	**2019**
Peter Ljunglöf	30	312	319	326	332	339
Other staff						
Doktorand	80	578	592	643	697	737
	Total, salaries (kSEK):	890	911	969	1029	1076

Other project related costs (kSEK)	**2015**	**2016**	**2017**	**2018**	**2019**
Travel and conferences	65	65	66	67	68
Personal computers	26			27	
Prototyping equipment	13	13	13	13	14
User evaluation		13	13	13	27
Costs for licenciate/PhD defense			20		68
Total, other costs (kSEK):	104	91	112	120	177

Total amount for which applied (kSEK)

2015	2016	2017	2018	2019
994	1002	1081	1149	1253

ALL FUNDING

Other VR-projects (granted and applied) by the applicant and co-workers, if applic. (kSEK)

Funds received by the applicant from other funding sources, incl ALF-grant (kSEK)

POPULAR SCIENCE DESCRIPTION

Popularscience heading and description (max 4500 char)

De senaste 10-20 åren har det uppkommit många olika metoder att interagera med datorer som används av miljoner människor runt hela världen. Den traditionella metoden att använda ett fysiskt tangentbord och en mus för att skriva och editera text har ifrågasatts av nya modaliteter såsom taligenkänning, pekskärmar, ögonstyrning och t.o.m. direktstyrning via hjärnvågor. Nya mobiltelefoner och surfplattor har gjort det enklare för människor att interagera med datorer, internet och andra människor jorden runt.

Under samma tid har mängden textinteraktioner ökat enormt -- t.ex., mer än 50 miljarder textmeddelanden skickas varje dag, och då räknar vi bara in SMS och chattklienter. Men de möjligheter som de nya modaliteterna erbjuder är i stort sett outforskade -- att författa en text ses konceptuellt som en stegvis process som går ut på att lägga till nya ord i slutet av det som skrivs. Det finns flera problem med detta synsätt, speciellt när det kommer till nya modaliteter såsom pekskärmar:

- Ett virtuellt tangentbord på en pekskärm är kognitivt belastande, eftersom användare inte får någon fysisk återkoppling. Istället måste användaren hela tiden hålla uppmärksamheten på det virtuella tangentbordet. Problemet blir ännu värre när skärmen är liten som på en mobiltelefon, eftersom det blir svårare att peka på rätt tangent när de ligger tätt.

- Att skriva text tecken för tecken är svårt i sig för kognitivt funktionshindrade användare, eftersom det kräver så många interaktioner med enheten. Notera att med kognitivt funktionshindrad menar vi inte enbart människor med kommunikativa eller fysiska funktionsnedsättningar, utan också normalutvecklade människor som gör något kognitivt krävande såsom att köra bil.

- Det stegvisa synsättet fokuserar på hur vi lägger till ny text, och ger inte så mycket stöd när vi vill ändra en existerande text. Det vanliga sättet är att placera markören på rätt ställe, och sedan använda tangentbordet för att ta bort den text som finns och lägga till ny. Effekten av detta blir att editering av text kommer att innehålla fler moment än att lägga till nya ord.

Det grundläggande problem som vi vill lösa i detta projekt är hur vi kan minska den kognitiva belastningen vid skrivande och editering av text på enheter med icke-traditionella användargränssnitt. Därför vill vi ändra det konceptuella synsättet om hur en text skapas. Istället för det traditionella synsättet att en text skapas genom att lägga till nya ord tills texten är klar, så är vårt nya synsätt att texter skapas i en dialog där användare och dator samarbetar för att successivt förbättra en text tills den är klar. Användaren kan välja att förändra vilken del av texten som helst, inte bara lägga till ord i slutet. På detta sätt kan man se författande som en tvådimensionell process i motsats till det endimensionella att bara utöka texten med nya ord.

Mer konkret så går interaktionen till så att användaren väljer ett ord eller en fras som hen vill ändra, och systemet föreslår alternativa formuleringar genom att böja, byta ut, ta bort eller lägga till ord. Användaren väljer någon alternativ formulering, texten ändras, och interaktionen kan fortsätta med nästa förändring. Det mer specifika forskningsproblemet som vi behöver lösa blir då hur systemet ska kunna föreslå bra alternativa formuleringar som hjälper användaren att slutföra sin uppgift.

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Name of applicant
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Date of birth
711031-2910

Title of research programme
MUSTE: Multimodal semantic text editing

Appendix A

Research programme

Vetenskapsrådet, Box 1035, SE-101 38 Stockholm, tel. +46 (0)8 546 44 000, vetenskapsradet@vr.se

MUSTE, Appendix A: Resarch Program

1 Purpose and aims

In the last years several different modes of human computer interaction have emerged and are used by millions of people all around the world. The traditional way of using a physical keyboard and a mouse for writing and editing text has been challenged by new interfaces such as speech recognition, touch screens, eye tracking and even brain computer interfaces. New mobile devices have made it easier for people to interact with their computers, the internet, and people around the world.

Until around 10 years ago, the only way for people to enter text on a computer was by using a typewriter keyboard, and this mode of interaction has fostered a view of text authoring as an incremental left-to-right process. Over the last years, touch-screen phones and tables have become increasingly common, and other modalities such as speech, eye tracking or even brain computer interfaces have emerged. Still this incremental view of text authoring has by and large continued. The amount of text interactions has increase enormously over the years – e.g., over 50 billion text messages are sent every day, only counting SMS and chat clients [27]. But still the full potential of the new modalities remains largely unexploited.

There are several problems with the incremental left-to-right view, especially when it comes to new modalities such as touch screens:

- A virtual touch-screen keyboard is cognitively demanding, since the user cannot get haptic feedback but instead have to constantly look at the virtual keys. This is worsened if the screen is small, making it more difficult to find the correct key to touch.
- Letter-by-letter text authoring is by itself demanding for cognitively disabled users, since it requires so many interactions with the device. By cognitively disabled, we do not only mean people with communicative or physical disabilities, but also normal-developed people doing something cognitively difficult such as driving a car.
- The incremental view focuses on how to enter new text, and does not give much help when it comes to editing existing text. This is standardly done by first positioning a cursor at the correct location, and then use the keyboard again to delete the existing text and add new. This has the effect that it is even more cognitively demanding to modify existing words than it is to enter new words.

Most solutions to these problems rely on using a built-in lexicon to do automatic spelling correction and predictive suggestions, but the available techniques still rely on the same conceptual idea that text is written incrementally left-to-right, using a typewriter keyboard.

1.1 Purpose of the project

The overall research problem that we want to solve in this project is to reduce the cognitive load when authoring and editing text on devices with non-traditional input modalities. We do this by changing the conceptual view of how text is authored. The traditional view is that a text is built by adding new words at the end until it is complete. Our view is instead that a text is authored by starting with an existing text and modifying it until it is satisfactory. The user can choose to modify any word or phrase in the text, not just at the end. In this sense, text authoring can be viewed as a two-dimensional process as opposed to the one-dimensional adding of words.

Our interpretation is therefore that text editing is a dialogue between the user and the system. The user selects a word or a phrase that she wants to modify, and the system suggests alternative formulations, by inflecting, replacing or deleting existing words, or by adding new words. The user selects an alternative formulation, the text gets modified, and the dialogue can continue with another step. The more specific research problem that we need to solve is then how to suggest good alternative formulations which help the user accomplish her task.

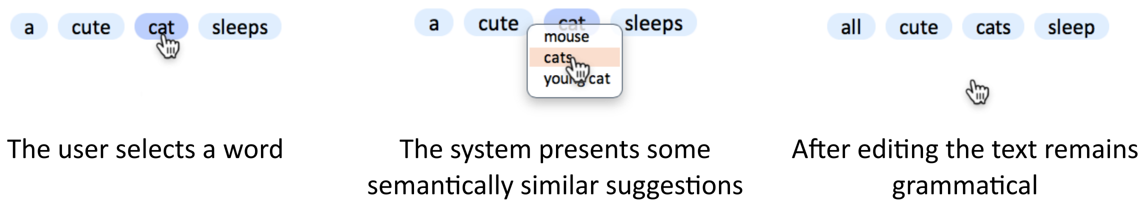

Figure 1: A simple example of multimodal semantic text editing

1.2 Multimodal semantic text editing

Our idea of text editing is exemplified in figure 1. In this example, the user selects a word (*"cat"*) that she wants to edit, after which the system presents a pop-up menu of possible choices. The user now selects one of the alternatives (*"cats"*, in plural), and the sentence is changed. One of our important goals is to reduce the cognitive load on the user by reducing the number of interactions with the system. Therefore the system must be helpful and give plausible suggestions. This is the reason why the system should use grammatical knowledge to inflect the words in the rest of the sentence so that it stays grammatical. In the example, the word *"sleeps"* is inflected, and the word *"a"* is replaced by *"all"*, to keep the sentence grammatical.

Note that we do not prohibit other modalities for text authoring. The editing process must start with an initial text somehow, which could be something returned by a speech recognizer, a prototypical utterance that is designed to be edited, or even a text that is entered using a keyboard.

More specifically, our aims in this project are as follows.

A computational theory for semantic suggestions When the user has selected a word or a phrase, the system needs to come up with plausible alternatives. The main problem here is to reduce the number of alternatives so that it can be presented to the user. For this we need a theory for calculating grammatically and semantically similar words and phrases.

A Grammar library for semantic text editing To be able to give grammatical and semantical suggestions, the system needs a notion of grammaticality. This will be done by developing a grammar library that can be used when creating applications for semantic text editing. The library will be based on an existing multilingual phrase-structure grammar [18].

An interpretation of editing gestures The text needs to be stored internally as some kind of semantical term, from which the system can calcluate new suggestions. This means that the we need to be able to interpret gestures by the user into editing operations on the unerlying semantic term.

Functioning prototypes that can be evaluated We will develop two prototypes for text editing applications. The prototypes will function as proof-of-concept that our theory is feasible, but we will also use them for evaluating the feasibility of our approach on users.

2 Survey of the field

The conceptual idea described in section 1.2, to edit an underlying abstract term by operating on the surface words, has not been described before in the literature. There has been lot of research on text authoring in different modalities, but most of it is focused on left-to-right text input, and there is not much work done on editing existing text. There has been some research on using a grammar for conceptual authoring, but either the user have to edit the abstract term directly, or it has been focused on left-to-right authoring.

Text input on mobile devices There are still mobile phones which do not use a touch screen, and instead use the numeric keypad for entering text. Usually they use predictive input which is based on a built-in lexicon and/or morphological rules [12]. For touch screen mobile devices, the standard way of editing text is to use a virtual keyboard, usually with a typical QWERTY layout. Since the keys are so small, the devices incorporate intelligent prediction and tries to remedy when you happen to touch a neighbouring key.

There have been lot of research on different alternatives to inputting letters, from swiping over the keyboard so that you don't have to lift your finger [7, 26], to using different layouts for the fingers [1, 4, 12]. Some devices have support for handwriting recognition, either via a stylus or directly by your finger [3], and there are also research that incorporates haptic or auditory feedback so that you don't have to look at the screen [25]

Almost all research are focused on incremental left-to-right authoring of letters, possibly augmented with prediction and error correction. The usual way of editing text is to move the cursor and selecting existing words by means of arrow keys or different kinds of touch screen gestures [5].

Alternative and augmentative communication (AAC) Communication tools that are designed for people with communicative disabilities, such as Autism Spectrum Disorder (ASD) or Cerebral Palsy (CP), usually have words or symbols as the basic entity, instead of letters. The reasons for this is to decrease the number of interactions with the device, and to reduce the cognitive load for people with communicative or cognitive disabilities.

The most common AAC communication tool is a grid with different words and/or symbols, which the user can select in sequence to author a text. Selection can be done using pointing, or by switch access scanning [22], or even eye-tracking [13]. Some devices have prediction for suggesting the next word and/or error correction for changing the order between the words, and in some cases grammatical information is included so that the device can inflect the words by grammatical function such as number or gender [14, 15], and there has been recent work on allowing the user to input the words/symbols in a non-grammatical order, and the system automatically selects the most probable sequence [28].

Syntax-based text editing The idea of using grammars to guide text editing is not new [2, 17], but it has not been considered much in the scope of mobile devices or AAC tools. There have been some attemps at multilingual authoring on mobile devices [6, 21], but the work that has been done has either required the user to edit the abstract grammar term directly or it has focused on left-to-right authoring.

We have developed the basic theory of syntax editing that was described in section 1.2 [10, 11]. Currently there is a working online prototype which uses a simple non-heuristic search strategy to find new replacement suggestions.[1] The current theory depends on the grammar formalism GF [20], which has its roots in type theory. In [9] we also showed that type theory can be used as the basis of a theory of human-computer dialogue, which could prove useful since in this project we view the process of text editing as a dialogue between the user and the computer. To be able to find similar suggestions, we need a notion of similarity between grammatical trees [24].

3 Project description

In section 3.1 we give a detailed description of the current status of our editing theory [11]. Sections 3.2, 3.3 and 3.5 explains how the theory can be used and evaluated in different applications, and section 3.4 describes the work plan of the project.

3.1 A theory of semantic text editing

The system consists of three implementation layers. At the bottom is the grammar layer, in which the domain grammar is defined. The only requirements on the grammar formalism are that 1) it is able to distinguish grammatical and ungrammatical semantic trees, 2) it should have a way of transforming trees into sequences of surface words, and 3) each word should have a backpointer saying which node in the tree is responsible for introducing that word.

Any grammar formalism with these properties should be usable in our approach. We use the Grammatical Framework [19, 20], which in addition has good support for multilingual grammars and comes with a useful resource grammar API for more than 20 different languages [18]. In GF, the semantic trees

[1] Online prototype: http://www.grammaticalframework.org/∼peter/grasp/

$$
\begin{array}{rcl}
cat & : & \mathrm{N} \\
mouse & : & \mathrm{N} \\
young & : & \mathrm{N} \to \mathrm{N} \\
cute & : & \mathrm{N} \to \mathrm{N} \\
a & : & \mathrm{N} \to \mathrm{NP} \\
all & : & \mathrm{N} \to \mathrm{NP} \\
sleep & : & \mathrm{VP} \\
chase & : & \mathrm{NP} \to \mathrm{VP} \\
sentence & : & \mathrm{NP}, \mathrm{VP} \to \mathrm{S}
\end{array}
$$

Figure 2: Example GF grammar

$$
\begin{array}{rcl}
cat^\circ & = & \{\mathsf{sg} : \text{“}cat\text{”} ; \mathsf{pl} : \text{“}cats\text{”}\} \\
mouse^\circ & = & \{\mathsf{sg} : \text{“}mouse\text{”} ; \mathsf{pl} : \text{“}mice\text{”}\} \\
young^\circ(x) & = & \{\mathsf{sg} : \text{“}young\text{”} + x\,!\,\mathsf{sg} ; \mathsf{pl} : \text{“}young\text{”} + x\,!\,\mathsf{pl}\} \\
cute^\circ(x) & = & \{\mathsf{sg} : \text{“}cute\text{”} + x\,!\,\mathsf{sg} ; \mathsf{pl} : \text{“}cute\text{”} + x\,!\,\mathsf{pl}\} \\
a^\circ(x) & = & \{\mathsf{s} : \text{“}a\text{”} + x\,!\,\mathsf{sg} ; \mathsf{num} : \mathsf{sg}\} \\
all^\circ(x) & = & \{\mathsf{s} : \text{“}all\text{”} + x\,!\,\mathsf{pl} ; \mathsf{num} : \mathsf{pl}\} \\
sleep^\circ & = & \{\mathsf{sg} : \text{“}sleeps\text{”} ; \mathsf{pl} : \text{“}sleep\text{”}\} \\
chase^\circ(x) & = & \{\mathsf{sg} : \text{“}chases\text{”} + x\,!\,\mathsf{s} ; \mathsf{pl} : \text{“}chase\text{”} + x\,!\,\mathsf{s}\} \\
sentence^\circ(x, y) & = & \{\mathsf{s} : x\,!\,\mathsf{s} + y\,!(x\,!\,\mathsf{num})\}
\end{array}
$$

Figure 3: Concrete syntax for the grammar

are called the *abstract syntax* and the surface words are called the *concrete syntax*. The translation from abstract syntax trees to concrete syntax words is called *linearisation*.

The middle layer consists of an API for modifying abstract syntax trees by specifying constraints on the tree and on its linearisation. The operations in the API tries to transform the given tree to obey the constraints, still keeping the new tree as semantically similar as possible. An example of a constraint can be that the linearisation of a given tree node must be different from the current linearisation.

The final layer is the graphical user interface, which communicates with the API to decide what alterantive suggestions should be displayed to the user. Internally, the text is *not* stored as the sequence of words that the user sees, but instead as semantic trees. The linearisation algorithm is used for displaying the sentences to the user, and everything that the user tries to do with a word is translated into a corresponding operation on the underlying tree.

3.1.1 Grammatical Framework

We start with some background on GF before we dwell into the the underlying editing theory on a more formal level.

GF abstract syntax The abstract syntax of a GF grammar consists of a finite number of typed functions, $f : A_1 \dots A_n \to A$ (where n can be 0). Given a function f we can create a tree $f(t_1 \dots t_n)$ of type A whenever $t_1, \dots, t_n$ are terms of types $A_1, \dots, A_n$, respectively. This makes the abstract syntax equivalent to a context-free grammar without terminal symbols, where the nonterminals correspond to GF types, and where the grammar rules have names. A simple example grammar is shown in Figure 2, and an example tree of type S licensed by this grammar is $sentence(a(cute(cat)), sleep)$.

GF concrete syntax The concrete syntax of a GF grammar is a compositional mapping from semantic trees to concrete terms, called the *linearisation*. The concrete terms can be quite complex and consist of strings, finite parameters, recursive records and inflection tables. However, we do not describe the concrete syntax in more detail, since it is not important for the later discussion. For more detailed information about the concrete syntax, we refer to the literature [19, 20] or to the GF online documentation.[2]

What is necessary to understand for the discussion in this section is that each word in a linearisation is introduced by exactly one node in the semantic tree. This makes it possible to translate an editing operation on a specific word into an editing operation on the corresponding node of the underlying tree. Note that GF does not make any distinction between leaf nodes and internal nodes, which means that any node in the tree can be responsible for a word.

Let's write t° for the linearisation of t. Compositionality can then be formulated as $f(t_1 \dots t_n)^\circ = f^\circ(t_1^\circ \dots t_n^\circ)$, where f° is the n-ary linearisation function corresponding to the n-ary abstract function f.

[2]Grammatical Framework: http://www.grammaticalframework.org/

The linearisation does not have to be a single string, but its result type can be different depending on the context. As an example, the linearisation of cat is an inflection table, which says that the corresponding strings should be *"cat"* in a singular context and *"cats"* in a plural context. The context is determined by the determiner, so the linearisation of a is a string that selects the singular value of its child, whereas $some$ specifies a plural child.

The concrete syntax of our example grammar is shown in Figure 3, and here are the linearisations of the example tree and a similar tree where the determiner a is replaced by all:

$$\begin{aligned} sentence(a(cute(cat)), sleep)^{\circ} &= \text{“}a\ cute\ cat\ sleeps\text{”} \\ sentence(all(cute(cat)), sleep)^{\circ} &= \text{“}all\ cute\ cats\ sleep\text{”} \end{aligned}$$

Note that the number of the determiner determines the inflection of both the noun and the verb, and that this inflection dependency is independent of the distance between the determiner and the verb. That the grammar formalism can handle long-distance dependencies is crucial if we want to write grammars for languages such as Swedish, German or Finnish.

3.1.2 Trees and tree editing

The *tree edit distance* is a distance measure between trees [24], which is a modification of the well-known Levenshtein string edit distance, where the distance between two trees is the number of editing operations required to transform one into the other. The allowed operations are 1) to *insert* a new node as a child of an existing node, 2) to *delete* a node, and 3) to *replace* an existing node with a new.

In our theory we use a variant of tree edit distance where nodes are ordered by semantic similarity, which is a notion that will be defined by the grammar. One possibility is to use Wordnet [16] for calculating the semantic similarity between two concepts.

Constrained linearisation In GF, not all strings in a linearisation of a subtree node have to be used in the linearisation of the full tree. In the example grammar, cat° contains two strings (*"cat"* and *"cats"*), but only one of them is used in $t_a = sentence(a(cute(cat)), sleep)^{\circ}$. We need to be able to talk about only the parts of a linearisation that are used, and for this purpose we define the *constrained linearisation* $[\![v]\!]_t$ of a subtree node v in a tree t. The intuition is that $[\![v]\!]_t$ consists of the strings in v° that are actually used when calculating t°. For the example tree t_a we get the constrained linearisations $[\![cat]\!]_{t_a} = \text{“}cat\text{”}$ and $[\![sleep]\!]_{t_a} = \text{“}sleeps\text{”}$.

Constraints for tree editing Each GF grammar rule $f : A_1 \ldots A_n \to A$ can be seen as a constraint on f-labeled nodes and its children. Checking that a tree is licensed by a grammar, which in GF is the same as checking that the tree is type-correct, can then be implemented as a constraint satisfaction problem [23]. Furthermore, when we formulate the grammar as constraints on trees, we can add additional constraints for specifying in more detail how our intended tree should look like.

By using tree constraints and a suitable semantic edit distance, we can describe a system for interactive tree editing. The system starts with a grammatical tree, and the user specifies additional constraints on the tree. The system then searches for the closest grammatical tree (in terms of semantic distance) that meets the constraints. This continues until the user is satisfied.

This approach lifts the level of tree editing from procedural to declarative: the user does not have to think about how to modify the tree, but instead she specifies what the tree should look like. We use two kinds of constraints:

- Structural constraints on the tree: We can specify whether a node should be or not be in the tree: $v \in V$ and $v \notin V$, respectively.
- Linearisation constraints: We can specify whether the (constrained) linearisation of a node shoule be or not be a given string: $[\![v]\!] = s$ and $[\![v]\!] \neq s$, respectively. There is also a linear precedence constraint: $[\![v]\!] \prec [\![v']\!]$, which means that $[\![v]\!]$ comes before $[\![v']\!]$ and that they are adjacent.

Example: Modifying a phrase The context-menu example shown in Figure 1, can be explained like this. Assume that we start with the following tree t_a:

$$t_\mathsf{a} = sentence(a(cute(cat)), sleep) \qquad t_\mathsf{a}^\circ = \text{"}a\ cute\ cat\ sleeps\text{"}$$

This tree has the nodes $sentence$, a, $cute$, cat and $sleep$. Now we want to say that the third word (whose corresponding node is cat) should be in plural form. This can be specified by the constraint $[\![cat]\!] = \text{"}cats\text{"}$. The system can then apply the tree editing operations to search for the most similar type-correct tree t'_a meeting the constraint. In this case it suffices to replace the determiner a by all:

$$t'_\mathsf{a} = sentence(all(cute(cat)), sleep) \qquad t'^\circ_a = \text{"}all\ cute\ cats\ sleep\text{"}$$

Semantic distance When the grammar is large, there might be several possible syntax trees that are equally close to the original tree (in terms of number of tree editing operations), making it difficult to decide which one would be a good alternative to suggest to the user. Our solution is to use a more fine-grained distance measure, where the cost of the editing operations depend on the specific values of the nodes that are involved .

If the example grammar contains the plural determiner $some$ in addition to all, there will be two possible solutions to the example problem. This is why we have to augment the grammar with a semantic distance measure between different abstract functions. In this case the grammar might state that $some$ is semantically more similar to a than all is, which therefore will suggest that the most similar resulting tree would be be $sentence(some(cute(cat)), sleep)$.

In a much the same way we can introduce similarity costs for deleting and inserting nodes; so that some functions prefer some other functions as parents, or siblings. This could be used for deciding which tree node a new phrase should attach to.

3.1.3 Syntactic editing of the surface string

Now we are ready to hide the semantic trees from the user altogether, and introduce semantic editing operations directly on the surface string. Our final goal is to implement a text editor where the user does not need any knowledge of formal grammars or semantic trees. Instead the text is presented to the user as a sequence of words, and in this section we define two intuitive editing operations on the text.

To implement these operations, we only make use of one GUI "gesture", to *select* an object (other names are to *click* or *point*). The user can either select a word or the empty space between two words. This makes it possible to implement the operations in a very limited interface, such as switch access scanning [22].

Since the user only modifies the surface string, we need a way of translating surface editing operations onto the underying semantic tree. We use the fact that in GF, each surface word belongs to one and only one node in the tree. So, when the user makes a gesture on a word $w \in [\![v]\!]_t$, we interpret it as a gesture on the underlying node v.

Modifying or deleting a phrase When the user selects a word $w \in [\![v]\!]_t$, the system first highlights the whole phrase $s = [\![v]\!]_t$ (which can contain more words than w), and then displays an editing menu for that phrase. To calculate the menu, we search for similar trees t' satisfying the constraint $[\![v]\!] \neq s$, i.e., so that v is linearised differently from the current linearisation. For each of these trees, we create a menu item consisting of the constrained linearisation $[\![v]\!]_{t'}$. A special case is when the node v is deleted from the tree, which we handle in the same way as the empty linearisation $[\![v]\!]_{t'} = \epsilon$.

If there are no matching similar trees, we increase the selection by moving up to the parent node v'. Then we try again to find similar trees satisfying the constraint $[\![v']\!] \neq s$, and so on.

When the user selects a menu item, the current tree t is replaced by the new tree t'. The selected node v remains highlighted. The example in Figure 1 shows what happens when the user selects the menu item "$cats$" for the selected word "cat".

Inserting a phrase If the user selects the space between two words $w_1 \in [\![v_1]\!]_t$ and $w_2 \in [\![v_2]\!]_t$, this is interpreted as the user wants to insert a phrase between the two nodes. We search for similar trees t' satisfying the constraints $[\![v_1]\!] \prec [\![v']\!] \prec [\![v_2]\!]$, where v' is the inserted node. Note that v' can be part of the original tree t, but does not have to. For each matching tree t', we create a menu item $[\![v']\!]_{t'}$. When the user selects a menu item, the tree t is replaced by t'.

3.2 Use cases

The following are two example use cases where multimodal text editing can prove useful. We plan to implement prototypes for both of them in the project. Some other possible use cases are discussed in section 3.5.

Mobile phrasebook translation aid The grammar formalism that we are using is multilingual, meaning that the underlying abstract syntax term is language-independent and can be linearized into several different languages, depending on the grammar that is used. Multilinguality can be incorporated into our text editing system, e.g., by showing linearisations of the abstract term in two different languages – the user's native language, and the language of the country that the user is visiting. The user can edit the sentence in her own language and all the time the sentence in the other language keeps updated. When the user is satisfied with the sentence, she can get the device to speak it out loud it in the other language and thus have a mobile communication tool between two languages. This communication tool will be more advanced than a traditional phrasebook, but it will still produce more correct translations than statistical machine translation (such as Google Translate).

AAC communication tool People with communicative disabilities, such as Autism Spectrum Disorder (ASD) or Cerebral Palsy (CP), often communicate via Augmentative and Alternative Communication (AAC) tools. Standardly these tools consist of a grid of input symbols which the user can select by pointing with a finger, or by using a switch or via eye gaze. The input symbols can be letters, or words, or even graphical symbols such as Blissymbolics, PCS or ARASAAC.

Most existing AAC communication tools are based on inputting words or symbols incrementally left-to-right, and it is often very cumbersome to edit something in the middle of an utterance, a task that our proposed editing system could make much easier. In addition, since the suggestions made by the system can be ordered by syntactic or semantic similarity, they will make more sense to the user and thus be a good alternative for people with cognitive disabilities. The multilingual grammar is also very useful in this case – the user can edit the text using graphical symbols, and the system will automatically edit an equivalent text in Swedish or English or whatever target language.

3.3 Evaluation

As we mentioned in the introduction, one of our main reasons for introducing the new approach to text editing is to be able to reduce cognitive load when authoring and editing text messages. When the prototypes are implemented we will perform rigorous evaluations, where we will investigate the efficiency and cognitive load when performing editing tasks, and compare with other editing interfaces.

These evaluations will be performed in collaboration with researchers experienced in evaluating cognitive load for dialogue systems, and with researchers experienced in evaluation of AAC tools (see section 6 for information about these collaborations).

3.4 Work plan

The project is budgeted for 5 years, with Peter Ljunglöf (PI) contributing 30% of his time, and there will be one PhD student that will work 80% during the whole project. A more detailed time plan follows here.

Year 1 During the first year we will further develop the algorithm for suggesting similar semantic trees so that it can work efficiently on large-sized grammars. We will also start developing a first prototype for the AAC communication tool described in section 3.2, together with an associated grammar that can translate between AAC symbols and Swedish.

Year 2 In the second year, a first version the AAC prototype will be finished and we will perform an initial evaluation on users. The evaluation will guide us on how the editing interface and the AAC grammar should be developed further. At the same time we will extend the grammar into more languages, such as the Scandinavian languages, Finnish, English, German, Spanish and others.

Year 3 We will integrate the AAC tool with other input methods, such as different ways of authoring the initial text that can be edited afterwards. This could be speech recognition or non-linear selection of AAC symbols from a grid of images [28].

We will improve upon the semantic similarity measure so that it can be learned automatically from existing lexica and corpora. At the same time we will start developing our second proof-of-concept, a multilingual phrasebook grammar that can be used by anyone by anyone with a mobile phone travelling abroad.

Year 4–5 Apart from refining the methods, interfaces and algorithms, we have time in the final years for an extensive evaluation of the multilingual phrasebook, and in particular for determining the efficiency and cognitive load, compared to alternative text authoring methods. Furthermore we will strenghten our collaboration with other research groups working on AAC communication, mobile translation or language learning.

3.5 Possible future use cases

In this project we only have the time to develop two proof-of-concept prototypes, one AAC tool and a mobile phrasebook translation app. Our methods have more potential uses, and here are two more possible useful tools which we won't pursue in this project.

Quick text messaging Most mobile phones have a possibility for sending quick text messages which you can use when you don't have the time to answer, or if you're busy with something else. These normally consists of a number of pre-stored messages that you cannot edit at all. By using keyboardless text editing, you can quickly personalize the message by just a few screen interactions, thus closing the gap between canned text and writing full text messages from scratch.

The editing system does not have to be controlled by pointing, instead we could use a voice-controlled menu system such as the VoiceCursor [8]. Then the user would not have to look at a screen at all, which makes it useful in cognitively disabled situations such as when driving a car.

Foreign language learning Multilingual text editing can also be used for implementing a tool for learning a foreign language. The idea is that it will work as an interactive textbook, where the user can read different texts and also experiment with and modify the texts. The system will be divided into modules dealing with different linguistic features, e.g., inflection, simple phrases and more advanced constructions. The system would also be able to generate quizzes, e.g., by generating two slightly different sentences in the source and target languages, and let the user modify the target sentence so that it becomes a correct translation of the source sentence.

4 Significance

The ideas that we want to pursue in this project suggest a completely new way of thinking about text editing, as a two-dimensional process where any word can be edited any time, instead of a one-dimensional process of adding new words at the end of a text. This is ground-breaking and has the potential to make a difference in the everyday life of anyone who wants to communicate efficiently using multimodal input, be it a mobile phone or an AAC communication tool.

Compared to a touch-screen with a virtual keyboard of ≈30 characters taking up half of the screen, our proposed method will allow more room for displaying the text, and the touchable areas will be larger. This will make it easier for users to select the intended word, which in turn will reduce the congnitive load. Furthermore, the conceptual simplicity of the interaction will make it possible to use different input modalities, such as eye tracking or switch access scanning.

5 Preliminary results

GRASP ("Grammatikbaserad språkinlärning") was a small project financed by Sunnerdahls Handikappfond in 2010 where we developed the basic theory of syntax editing that was described in section 1.2 [10, 11]. There is a working online prototype which uses a simple non-heuristic search strategy to find new replacement suggestion.[3] We are currently fine-tuning the prototype and will demonstrate it on *Vetenskapsfestivalen* here in Gothenburg 8 May 2014.

6 Collaboration

CLT (Centre for Language Technology) is an organization for collaboration between language technology researchers at the at the University of Gothenburg and Chalmers University of Technology. We will work in close collaboration with the developers of Grammatical Framework (Aarne Ranta, Thomas Hallgren and other people in the Grammar Technology Lab at CLT) when we develop the grammars and algorithms for the project, by building upon existing grammars and algorithms.

The VR project REMU[4] is a project for reliable multilingual communication, which also builds upon GF technology. Our project is independent from and has a different purpose than REMU, where we focus on the interaction and cognitive load of text editing, while REMU focuses on making grammars more reliable by using formal methods and logical reasoning. There are possible synergy effects between the projects, which we of course will make use.

The Dialogue Technology Lab at CLT has long experience on developing and evaluating dialogue systems (Staffan Larsson, Simon Dobnik and others), and in particular they have experience on how to reduce and evaluate cognitive load. The user evaluations will be conducted in collaboration with them.

DART (Centre for Augmentative and Alternative Communication and Assistive Technology, Sahlgrenska University Hospital, Gothenburg) is the leading centre for alternative and augmentative communication in Western Sweden, and has long experience of working with people with communication difficulties, as well as conducting research on AAC and accessive technologies. Peter Ljunglöf has collaborated with DART in several projects about using language technology in AAC tools (Katarina Heimann Mühlenbock, Mats Lundälv and others). We will collaborate with DART in the design and evaluation of the AAC prototype tool.

7 Ethical considerations

There are always ethical considerations when conducting user evaluations. Ethics is even more important when it comes to people with disabilities, since they are relatively few and in a vulnerable position. Therefore it is customary in Sweden that all research on disabled people should be approved by an independent ethics committee. Our collaborators DART has long experience in designing user evaluations and writing ethics applications, which we of course will take advantage of.

8 References

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[6] Janna Khegai, Bengt Nordström, and Aarne Ranta. Multilingual syntax editing in GF. In A. Gelbukh, editor, *CICLing–2003: Intelligent Text Processing and Computational Linguistics*, LNCS 2588, pages 453–464. Springer-Verlag, 2003.

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[8] Staffan Larsson, Alexander Berman, and Jessica Villing. Multimodal menu-based dialogue with speech cursor in DICO II+. In *Proceedings of ACL-HLT'11: 49th Annual Meeting of the Association for Computational Linguistics, Systems Demonstrations*, Portland, Oregon, 2011.

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VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

Kod
2014-27815-116181-10

Name of applicant
Ljunglöf, Peter

Date of birth
711031-2910

Title of research programme
MUSTE: Multimodal semantic text editing

Appendix B

Curriculum vitae

MUSTE, Appendix B: Curriculum Vitae for Peter Ljunglöf

1 Higher education

2002 Ph.Lic. in Computer Science. Title: *Pure Functional Parsing – an advanced tutorial*, supervised by prof. Aarne Ranta. Department of Computing Science, University of Gothenburg and Chalmers University of Technology.

1999 M.A. in Mathematics. Title: *Konstruktiv mängdteori*, supervised by prof. Jan Smith. Department of Mathematics, University of Gothenburg.

2 Degree of doctor

2004 PhD in Computer Science. Title: *Expressivity and Complexity of the Grammatical Framework*, supervised by prof. Aarne Ranta. Department of Computing Science, University of Gothenburg and Chalmers University of Technology. The area of my thesis work was in formal language theory, which is an area in computational linguistics and computer science.

3 Postdoctoral positions

2008 *Dialogue Systems and Type Theory*, 9 month postdoc project funded by CLT, the Centre for Language Technology at the University of Gothenburg.
I investigated dialogue systems from a type-theoretical perspective, aiming at making dialogue systems more logically well-founded.

4 Qualification required for appointment as a docent

2013 I got appointed as "oavlönad docent" at the University of Gothenburg in August 2013.

5 Present position

2011–present I am Assistant Professor with tenure track (in Swedish "biträdande lektor"), at the Department of Computer Science and Engineering, University of Gothenburg and Chalmers University of Technology. My tenure ends in December 2014, and I will apply for a position of Associate Professor ("lektor").

6 Previous positions

1998–1999 Research Assistant at the EU project TRINDI[4], and the Swedish projects INDI[5] and SDS.[6] Department of Linguistics, University of Gothenburg.

1999–2004 Doctoral Student. Department of Computing Science, University of Gothenburg and Chalmers University of Technology.

2005–2006 Researcher at the EU project TALK,[7] and Lecturer. Department of Linguistics, University of Gothenburg.

2007–2007 Researcher at the Vinnova project DICO[8] and Lecturer. Department of Linguistics, University of Gothenburg.

2008–2009 Researcher and Lecturer. Department of Linguistics, University of Gothenburg.

2009–2010 Researcher at DART (Centre for Augmentative and Alternative Communication and Assistive Technology). Sahlgrenska University Hospital, Gothenburg.

2009–2010 Research Engineer, Språkbanken, Department of Swedish Language, University of Gothenburg.

[4] TRINDI (Task Oriented Instructional Dialogue), EC Project LE4–8314
[5] INDI (Information Exchange in Dialogue), Riksbankens Jubileumsfond 1997–0134
[6] SDS (Swedish Dialogue Systems), NUTEK/HSFR Language Technology Project F1472/1997
[7] TALK (Talk and Look: Tools for Ambient Linguistic Knowledge), EU Project IST–507802
[8] DICO, Vinnova project P28536–1

7 Interruption in research

2001–2004 During my PhD studies I was on parental leave for 5 months.

2005–2008 After my PhD degree I was on parental leave for a total of 10 months.

8 Supervision

2010–2014 I am co-supervisor for PhD student Håkan Burden (main supervisor is Rogardt Heldal), who will defend his thesis in 2014.

9 Additional information

Project coordination

2009 *TRIK* (En talande och ritande robot för barn med kommunikativa funktionshinder), funded by the Promobilia foundation and Magn. Bergvall's foundation, ca. 550 kSEK, *Principal Investigator*.
We developed and evaluated a setup involving a communication board (for manual sign communication) and a drawing robot, which can communicate with each other via spoken language. The purpose is to help children with severe communication disabilities to learn language, language use and cooperation.

2010–2011 *GRASP* (Grammatikbaserad språkutveckling), funded by Sunnerdahls Handikappfond, ca. 300 kSEK, *Principal Investigator*.
We developed an interactive language and grammar learning system for children with communicative disabilities. The child can change and rearrange words in the text, and the system will automatically move and inflect the other words, so that the text always is grammatically correct.

2010–2011 *Lekbot* (En pratande och lekande robot för barn med funktionshinder), Vinnova project P37299–1, ca. 1500 kSEK, *Local Coordinator, Co-applicant* (PI Fredrik Kronlid, Talkamatic AB).
This project was a continuation to the TRIK project. The aim of the new project was to develop a working prototype that could be evaluated on children with communicative disabilities, in their normal environment. The final prototype is a talking and playing robot which can help disabled children to learn and play, together with other children.

2011–2012 *Pratmakaren* (Pratmakaren – uppläsning av textremsor med talsyntes), Post- och Telestyrelsen, ca. 400 kSEK, *Local Coordinator, Co-applicant* (PI Maria Olsson, DART).
We developed a tool that enables the computer to read subtitles of movies and TV shows aloud. The target audience is people who have trouble reading subtitles while watching a movie, for example people with visual impairments and people with reading difficulties.

Organization of conferences

2011–2013 Member of the organising committee for SLPAT, the 2nd, 3rd and 4th Workshop on Speech and Language Processing for Assistive Technologies: 2011 (Edinburgh), 2012 (Montréal) and 2013 (Grenoble).

2014 Publicity chair for EACL, the 14th Conference of the European Chapter of the Association for Computational Linguistics, to be held in Gothenburg 26–30 April 2014.

Positions of Trust

2012–present Member of the steering group of MLT, Masters programme in Language Technology, at the Department of Philosophy, Linguistics and Theory of Science, University of Gothenburg.

2013–present Member of the steering group of CLT, Centre of Language Technology (Focus Area of Research), University of Gothenburg.

Appendix C

List of publications

MUSTE, Appendix C: Publication list for Peter Ljunglöf

For the citation counts I have used Google Scholar, and all my papers are available online from my personal webpage:

http://scholar.google.se/citations?user=8GVoEBgAAAAJ

http://www.cse.chalmers.se/∼peb/bibliography.html

1 Peer-reviewed journal articles

Peter Ljunglöf. Functional chart parsing of context-free grammars. *Journal of Functional Programming*, 14(6):669–680, 2004. Number of citations: 0.

Koen Claessen and Peter Ljunglöf. Typed logical variables in Haskell. *Electronic Notes in Theoretical Computer Science*, 41(1), 2000. Number of citations: 31.

2 Peer-reviewed conference contributions

2.1 Peer-reviewed full articles

Krasimir Angelov and Peter Ljunglöf. Fast statistical parsing with parallel multiple context-free grammars. In *EACL'14, 14th Conference of the European Chapter of the Association for Computational Linguistics*, Gothenburg, Sweden, 2014. Number of citations: 0.

Håkan Burden, Rogardt Heldal, and Peter Ljunglöf. Enabling interface validation through text generation. In *VALID 2013, 5th International Conference on Advances in System Testing and Validation Lifecycle*, Venice, Italy, 2013. Number of citations: 0.

Peter Ljunglöf. Practical parsing of parallel multiple context-free grammars. In *TAG+11, 11th International Workshop on Tree Adjoining Grammar and Related Formalisms*, Paris, France, 2012. Number of citations: 0.

Peter Ljunglöf, Sandra Derbring, and Maria Olsson. A free and open-source tool that reads movie subtitles aloud. In *SLPAT'12: 3rd Workshop on Speech and Language Processing for Assistive Technologies*, Montréal, Canada, 2012. Number of citations: 0.

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Peter Ljunglöf, Alexander Berman, Britt Claesson, Stina Ericsson, Fredrik Kronlid, Ingrid Mattsson Müller, and Cajsa Ottesjö. Lekbot: A talking and playing robot for children with disabilities. In *SLPAT'11: 2nd Workshop on Speech and Language Processing for Assistive Technologies*, Edinburgh, UK, 2011. Number of citations: 1.

Peter Ljunglöf. trindikit.py: An open-source Python library for developing ISU-based dialogue systems. In *IWSDS'09, 1st International Workshop on Spoken Dialogue Systems Technology*, Kloster Irsee, Germany, 2009. Number of citations: 3.

Sandra Derbring, Peter Ljunglöf, and Maria Olsson. SubTTS: Light-weight automatic reading of subtitles. In *Nodalida'09: 17th Nordic Conference of Computational Linguistics*, 2009. Number of citations: 3.

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Peter Ljunglöf and Staffan Larsson. A grammar formalism for specifying ISU-based dialogue systems. In *GoTAL'08, 6th International Conference on Natural Language Processing*, volume 5221 of *Springer LNCS/LNAI*, Gothenburg, Sweden, 2008. Number of citations: 8.

Peter Ljunglöf, Staffan Larsson, Katarina Mühlenbock, and Gunilla Thunberg. TRIK: A talking and drawing robot for children with communication disabilities. In *NordiCHI'08 Workshop: Designing Robotic Artefacts With User- and Experience Centred Perspectives*, 2008. Number of citations: 0.

Peter Ljunglöf. A grammar formalism for specifying ISU-based dialogue systems. In *Londial'08, 12th Workshop on the Semantics and Pragmatics of Dialogue*, London, 2008. Number of citations: 0.

Peter Ljunglöf. Converting Grammatical Framework to Regulus. In *SPEECHGRAM, Workshop on Grammar-Based Approaches to Spoken Language Processing*, Prague, 2007. Number of citations: 1.

Björn Bringert, Robin Cooper, Peter Ljunglöf, and Aarne Ranta. Multimodal dialogue system grammars. In *Dialor'05, 9th Workshop on the Semantics and Pragmatics of Dialogue*, Nancy, France, 2005. Number of citations: 20.

Håkan Burden and Peter Ljunglöf. Parsing linear context-free rewriting systems. In *IWPT'05, 9th International Workshop on Parsing Technologies*, Vancouver, Canada, 2005. Number of citations: 23.

Peter Ljunglöf. A polynomial time extension of parallel multiple context-free grammar. In *LACL'05, 5th Conference on Logical Aspects of Computational Linguistics*, Bordeaux, France, 2005. Number of citations: 10.

Staffan Larsson, Peter Ljunglöf, Robin Cooper, Elisabet Engdahl, and Stina Ericsson. GoDiS – an accommodating dialogue system. In *ANLP–NAACL'00 Workshop on Conversational Systems*, Seattle, Washington, 2000. Number of citations: 54.

Peter Bohlin, Robin Cooper, Elisabet Engdahl, and Staffan Larsson. Information states and dialogue move engines. In Jan Alexandersson, editor, *IJCAI-99 Workshop on Knowledge and Reasoning in Practical Dialogue Systems*, 1999. (*Note:* Back in 1999, my last name was Bohlin). Number of citations: 45.

2.2 Peer-reviewed short papers

Håkan Burden, Rogardt Heldal, and Peter Ljunglöf. Opportunities for agile documentation using natural language generation. In *ICSEA 2013, International Conference on Software Engineering Advances*, Venice, Italy, 2013. Number of citations: 0.

Peter Ljunglöf. Type-based human-computer interaction. In *TYPES 2013: Types for Proofs and Programs*, Toulouse, France, 2013. Number of citations: 0.

Peter Ljunglöf and Magdalena Siverbo. A bilingual treebank for the FraCaS test suite. In *SLTC'12, 4th Swedish Language Technology Conference*, Lund, Sweden, 2012. Number of citations: 1.

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Peter Ljunglöf. TRIK: A talking and drawing robot for children with communication disabilities. In *DiaHolmia'09, 13th Workshop on the Semantics and Pragmatics of Dialogue*, Stockholm, Sweden, 2009. Number of citations: 4.

Peter Ljunglöf, Staffan Larsson, Katarina Mühlenbock, and Gunilla Thunberg. TRIK: A talking and drawing robot for children with communication disabilities. In *Nodalida'09: 17th Nordic Conference of Computational Linguistics*, 2009. Number of citations: 4.

Peter Ljunglöf. Transition-based parsing. In *SLTC 2008: Proceedings of the Swedish Language Technology Conference*, Stockholm, Sweden, 2008. Number of citations: 0.

4 Books and book chapters

4.1 Book chapters

Peter Ljunglöf and Mats Wirén. Syntactic parsing. In Nitin Indurkhya and Fred J. Damerau, editors, *Handbook of Natural Language Processing, 2nd edition*, chapter 4. CRC Press, Taylor and Francis, 2010. ISBN 978-1420085921. Number of citations: 6.

4.2 Proceedings

Jan Alexandersson, Peter Ljunglöf, Kathleen F. McCoy, François Portet, Brian Roark, Frank Rudzicz, and Michel Vacher, editors. *Proceedings of SLPAT'13: 4th Workshop on Speech and Language Processing for Assistive Technologies*, Grenoble, France, 2013. Association for Computational Linguistics. Number of citations: 0.

Jan Alexandersson, Peter Ljunglöf, Kathleen F. McCoy, Brian Roark, and Annalu Waller, editors. *Proceedings of SLPAT'12: 3rd Workshop on Speech and Language Processing for Assistive Technologies*, Montréal, Canada, 2012. Association for Computational Linguistics. Number of citations: 0.

Melanie Fried-Oken, Peter Ljunglöf, Kathleen F. McCoy, and Annalu Waller, editors. *Proceedings of SLPAT'11: 2nd Workshop on Speech and Language Processing for Assistive Technologies*, Edinburgh, UK, 2011. Association for Computational Linguistics. Number of citations: 0.

4.3 Theses and project deliverables

Peter Ljunglöf. *Expressivity and Complexity of the Grammatical Framework*. PhD thesis, University of Gothenburg and Chalmers University of Technology, Gothenburg, Sweden, 2004. Number of citations: 43.

Stina Ericsson (editor), Gabriel Amores, Björn Bringert, Håkan Burden, Ann-Charlotte Forslund, David Hjelm, Rebecca Jonson, Staffan Larsson, Peter Ljunglöf, Pilar Manchón, David Milward, Guillermo Pérez, and Mikael Sandin. Software illustrating a unified approach to multimodality and multilinguality in the in-home domain. Deliverable D1.6, TALK Project, 2007. Number of citations: 26.

David Milward, Gabriel Amores, Nate Blaylock, Staffan Larsson, Peter Ljunglöf, Pilar Manchón, and Guillermo Pérez. Dynamic multimodal interface reconfiguration. Deliverable D2.2, TALK Project, 2006. Number of citations: 0.

Peter Ljunglöf, Gabriel Amores, Robin Cooper, David Hjelm, Pilar Manchón, Guillermo Pérez, and Aarne Ranta. Multimodal grammar library. Deliverable D1.2b, TALK Project, 2006. Number of citations: 9.

Peter Ljunglöf, Gabriel Amores, Håkan Burden, Pilar Manchón, Guillermo Pérez, and Aarne Ranta. Enhanced multimodal grammar library. Deliverable D1.5, TALK Project, 2006. Number of citations: 2.

Peter Ljunglöf (editor), Björn Bringert, Robin Cooper, Ann-Charlotte Forslund, David Hjelm, Rebecca Jonson, Staffan Larsson, and Aarne Ranta. The TALK grammar library: an integration of GF with TrindiKit. Deliverable D1.1, TALK Project, 2005. Number of citations: 0.

Björn Bringert, Robin Cooper, Peter Ljunglöf, and Aarne Ranta. Development of multimodal and multilingual grammars: viability and motivation. Deliverable D1.2a, TALK Project, 2005. Number of citations: 0.

6 Open access computer programs that I have developed

All my open-source computer programs are available in the public repositories Github and Googe Code:

https://github.com/heatherleaf

http://code.google.com/u/peter.ljunglof@heatherleaf.se

2013–present *Open Blissymbolics repository*, https://github.com/blissymbolics/blissymbols
A database of all official Blissymbols, and their definitions, plus some additional utilities for editing and displaying Blissymbols.

2013–present *PMCFG* (Exchange format and tools for PMCFG), https://github.com/PMCFG/PMCFG
This repository defines a common exchange format for grammars that can be encoded as Parallel Multiple Context-Free Grammars, i.e., most phrase-structure formalisms)

2011–present *GRASP* (Grammatikbaserad språkredigering), https://github.com/heatherleaf/grasp
A pedagogical tool to support language learning and training for children with communicative disabilities. The system has a graphical interface, where the user can move, replace, add, and in other ways modify, words or phrases. The system keeps the sentence grammatical, by automatically rearranging the words and changing inflection, if necessary.

2009–present *NLTK* (Natural Language Toolkit), http://www.nltk.org/
The Natural Language Toolkit is a suite of open source Python modules, data and documentation for research and development in natural language processing. I am part of the core development team, with my main responsibility being the implementations of grammars and parsing algorithms.

2012–2013 *MCFParser.py*, https://github.com/heatherleaf/MCFParser.py
Efficient parsing algorithms for Parallel Multiple Context-Free Grammars, written in Python.

2012–2013 *SubTTS* (Automatic reading of movie subtitles), https://github.com/heatherleaf/subtts-mac
SubTTS reads a subtitles file, and uses a speech synthesiser to read the subtitles aloud while you are watching the movie.

2009–2012 *KronoX*, http://code.google.com/p/kronox
This is a time tracking program for Mac OSX, written in Objective-C, my only project not related to language technology.

2009–2010 *js-chartparser*, http://code.google.com/p/js-chartparser
This is a left-corner chartparser for SRGS/SISR grammars, implemented in Javascript for efficient client side parsing.

2009–2010 *py-trindikit*, http://code.google.com/p/py-trindikit
This is an open-source reimplementation of TrindiKit in the object-oriented language Python.

2000–2007 *Grammatical Framework*, http://www.grammaticalframework.org/
During my PhD studies and some time thereafter I was one of the core developers of the Grammatical Framework, mostly responsible for parsing algorithms and grammar conversions, but I have also made contributions to the semantics of the language constructs.

2004 *Prolog MCFG Parsing Library*, http://code.google.com/p/prolog-mcfg-parser
This is a Prolog implementation of some parsing algorithms for Multiple Context-Free Grammars.

2002 *Haskell Functional Parsing Library*, http://code.google.com/p/haskell-functional-parsing
This library contains Haskell implementations of several parsing algorithms, both for functional parser combinators, and for context-free grammars.

2000–2004 *SKVATT* (Feature structures in Prolog), http://code.google.com/p/prolog-skvatt
This is a simple extension of Prolog to get feature structures and feature structure unification, natively in the programming language. It also contains parsing and generation algorithms.

1999–2001 *TrindiKit*, http://www.ling.gu.se/projekt/trindi/trindikit
I was one the original developers of the TrindiKit toolkit for building and experimenting with ISU-based dialogue systems. It is implemented in Sicstus Prolog.

VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

Kod
2014-27815-116181-10
Name of applicant
Ljunglöf, Peter
Date of birth
711031-2910

Title of research programme

Appendix N

Budget and research resources

Vetenskapsrådet, Box 1035, SE-101 38 Stockholm, tel. +46 (0)8 546 44 000, vetenskapsradet@vr.se

MUSTE, Appendix N: Budget

We plan to hire one doctoral student at 80% for 5 years, who will need supervision amounting to 10% of the time of the main applicant . Furthermore, the main applicant will work 20% at the project. Other costs are travel, computer equipment, and costs related to user evaluations and licenciate/PhD defenses. The computer equipment consists of computers to the people working in the project, but also of tablet devices for prototyping. All amounts are in kSEK, and indirect costs are included.

	2015	2016	2017	2018	2019
Peter Ljunglöf, 30%	312	319	326	332	339
PhD student, 80%	578	592	643	697	737
Travel and conferences	65	65	66	67	68
Personal computers	26			27	
Prototyping equipment	13	13	13	13	14
User evaluation		13	13	13	27
Lic/PhD defense			20		68
Total per year	994	1003	1082	1150	1253

Kod
2014-27815-116181-10

Dnr
2014 -

Name of applicant
Ljunglöf, Peter

Date of birth
711031-2910

Reg date
2014-04-09 08:27:52

Project title
MUSTE: Multimodal semantic text editing

NT

NT-2

Research grants NT April 9, 2014
Project Research Grant
*Övrigt generellt
Göteborgs universitet

Appendix S

Signatures

2015	2016	2017	2018	2019
994	1002	1081	1149	1253

2015-01-01 -- 2019-12-31

Applicant

Date

Head of department at host University

Clarifi cation of signature

Telephone

A signature on the application is required not only from the applicant but also from the authorised representative of the administrating organisation/institution or equivalent (normally the head of the department or establishment where the research is to be conducted). The signature confirms that the department can accommodate the proposed research, position or equipment; that the costing in the application is approved for the department's part, that any proposed experimentation on human or animal subjects has been reported, and that the applicant has reported any secondary occupations and commercial ties (s)he may have, and nothing inconsistent with good research practice has thereby emerged. The applicant must have discussed these conditions with the representative of the administrating organisation/institution or equivalent before the latter approves and signs the application.

NOTE the exceptions!
Please note that a different procedure applies for the following types of grants:

- Infrastructure- Operation Grants
- Infrastructure- Grants for Expensive Equipment
- Infrastructure- Grants for Large Databases
- Framework Grant SIMSAM
- International Recruitment

For these types of grants the vice-chancellor, instead of the head of department, must sign Appendix S. Thereby (s)he confirms the commitments of the administrative organization. The details are specified in the Call for Proposals, published at www.vr.se.

Vetenskapsrådets noteringar
Kod

2014-27815-116181-10

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