Challenges in assistive technology development for an endangered language: an Irish (Gaelic) perspective

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Abstract

This paper describes three areas of assistive technology development which deploy the resources and speech technology for Irish (Gaelic), newly emerging from the ABAIR initiative. These include (i) a screenreading facility for visually impaired people, (ii) an application to help develop phonological awareness and early literacy for dyslexic people (iii) a speech-enabled AAC system for non-speaking people. Each of these is at a different stage of development and poses unique challenges: these are discussed along with the approaches adopted to address them. Three guiding principles underlie development. Firstly, the sociolinguistic context and the needs of the community are essential considerations in setting priorities. Secondly, development needs to be language sensitive. The need for skilled researchers with a deep knowledge of Irish structure is illustrated in the case of (ii) and (iii), where aspects of Irish linguistic structure (phonological, morphological and grammatical) and the striking differences from English pose challenges for systems aimed at bilingual Irish-English users. Thirdly, and most importantly, the users and their support networks are central – not as passive recipients of ready-made technologies, but as active partners at every stage of development, from design to implementation, evaluation and dissemination.

1 Introduction

This paper discusses ongoing research which aims to ensure that the emerging speech technologies and resources emerging for Irish (Gaelic) are made available in assistive technologies that cater for those with disabilities.

The rapid advances and increasingly ubiquitous use of speech and language technologies is viewed as a 'digital timebomb' within endangered language communities (Evans, 2018). Like other endangered languages, Irish lives in the shadow of a 'major' world language (English). In such a bilingual context, the unequal provision of speech and language technologies in the two languages is obliging native speakers to switch to the major language in more and more domains of activity – accelerating the already catastrophic rate at which endangered languages are being lost.

Nonetheless, these same technologies can offer a lifeline that might defuse this timebomb (Ní Chasaide et al., 2019a). Making the language part of this digital revolution provides the community with new ways to document, maintain and revive their language (Ní Chasaide et al., 2019a).

The ABAIR initiative has for a number of years been developing speech (linguistic) resources and core speech technologies for Irish. Text-to-speech synthesis (TTS) systems have been developed and are publicly available[1]. A beta automatic speech recognition system (ASR) is now also developed and will be launched later this year. Developing core technologies without parallel development of assistive technologies leaves people with

[1] www.abair.ie

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disabilities without a voice – an invisible minority within a minority.

A central concern of ABAIR is to develop applications that make both resources and technologies readily available to all members of the language community. Unlike the situation of the 'major' world languages, where application development is driven by commercial concerns, for minority or endangered languages, the most urgent needs of the community should dictate development priorities. ABAIR is therefore developing applications targeting the general public, the educational sector and, importantly, those with speech and communication disabilities. The involvement of the community and of specific end-user groups is central in all this development.

This paper describes three areas of assistive technology, in which work is at different stages of development. These include (i) applications for visually impaired people, (ii) applications for dyslexic people, and (iii) applications for nonspeaking people. Sections 4, 5, and 6 outline the development so far in these areas. As essential background, Section 2 explains the socio-linguistic context, while Section 3 focusses on difficulties specific to minority and endangered languages.

While some aspects of our work are specific to the Irish context, many of the challenges – and the approaches to overcoming them – are relevant to the wider endangered language community, and especially to minority language users with disabilities who are doubly excluded from their language through want of appropriate assistive technologies.

2 The socio-linguistic context

Irish (Gaelic) is classified by UNESCO as definitely endangered (Moseley, 2012). It is spoken as a community language in Gaeltacht regions, mostly on the western seaboard (see Figure 1). Although there are over 96,000 people living in Gaeltacht areas, the language is losing ground. Irish is recognised as the first official language of Ireland and since 2007 as an official language of the EU.

In this paper we focus particularly on the needs of school-going children and adolescents. As the first official language of Ireland, Irish is a core subject for all in primary and secondary school. Furthermore, interest in Irish immersion education (where all the schooling is carried out through Irish) is burgeoning and has seen steady growth in recent years (Gaeloideachas, 2022). Thus, between Gaeltacht schools and Irish immersion schools outside the Gaeltacht, Irish is the language of education for more than 66,000 children in Ireland (Gaeloideachas, 2022). In these schools, almost one in ten students have additional educational needs (Nic Aindriú, Ó Duibhir & Travers, 2020).

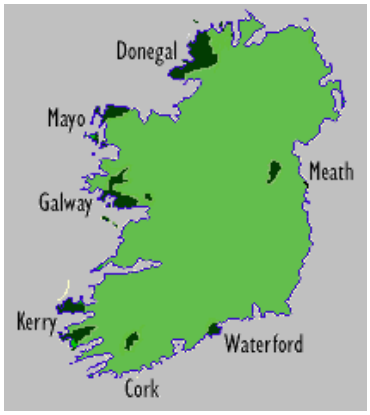

Figure 1: Map showing Gaeltacht (Irish speaking regions) in Ireland (shaded black).

The need for assistive technologies varies thus for different cohorts: in Gaeltacht native-speaker communities they can be key to inclusion in the family and in the life of the language community as well as being essential to participation in education. For those attending Irish immersion education outside the Gaeltacht, assistive technologies are paramount for engagement with the curriculum and for general communication with peers and teachers. For those in English-medium education, assistive technologies are essential to participate in Irish language learning and in the rich cultural online world of Irish.

Despite the transformative role of assistive technology in inclusion and education (e.g. Borg et al, 2021), despite the Government's commitment to promote the Irish language and despite the commitment to provide equal access to those with disabilities, the needs of the latter are largely overlooked when it comes to assistive technologies for Irish. There is little reference to access and disability in the above mentioned 20 Year Strategy for the Irish Language 2010-2030, and there is no reference to the Irish language or to bilingualism in the foremost report on the provision of assistive technology in Ireland (Cullen et al, 2010). This blind spot is also highlighted by the fact that speech and language therapists and other professionals are typically not trained to support bilingual people (Ní Chinnéide, 2009). The sense of disempowerment

of those who need assistive technologies also emerges in a recent survey (Nic Corcráin, 2021)

3 Challenges for minority languages

To develop speech and language technologies (and applications) for a minority language brings many challenges, which are not necessarily appreciated by those involved in technology development in a 'major' language. As in many endangered languages, Irish has no spoken standard variety. There are 3 main dialects and a number of sub-dialects – all of which are deemed standard. The difference between dialects is considerable, particularly as pertains to pronunciation (prosodic and segmental) aspects and to the morphology. A written standard was established in 1958 with the publication of *An Caighdeán Oifigiúil* 'The Official Standard'. It is a compromised hybrid standard which draws on features from the individual dialects to suggest standardised spelling and grammar forms to be taught in schools. However, it is somewhat problematic, as the 'standard' does not correspond to the spoken forms of any given dialect.

These facts have many implications for speech technology development, and determine the parameters for technology development, if one aspires to technologies that are truly useful to the language communities. At the very least they need to cater for the various dialects of the potential users. Thus, in developing TTS for Irish in the ABAIR initiative, it was clear from the outset that multidialect speech synthesis (TTS) systems were a fundamental necessity. The current systems available on the ABAIR webpage include voices (male, female) in the three main dialects. Further dialects are being developed and ultimately all dialects targeted. Similarly, in developing speech recognition (ASR), it is crucial to be able to handle the different native speaker dialects. Consequently, corpus collection to date has focussed on native speakers from the different Gaeltacht areas. Not surprisingly therefore, the current beta ASR system is much more accurate for native speaker speech than for non-native-speaker speech, whether from proficient speaker or learner. Ultimately, the system will need to be capable of catering for all potential users.

The bilingual context of most endangered languages brings additional challenges. Code switching is frequent, and speech technologies need to be able to deal with it. For certain kinds of assistive technologies, linguistic differences between the endangered and 'major' language raises issues require language-specific resource development to underpin the technology.

4 An Irish screenreading facility

A screenreading facility for Irish has been developed as a plugin for the NVDA screenreader, prompted by urgent pleas from parents and grandparents of visually impaired children in the Gaeltacht or attending Irish-medium schools. For these children, the lack of access to written forms of Irish undermined their education (there are only 3 books available in Braille for Irish). Note that almost 55,000 people are blind or visually impaired in Ireland – 4,701 of whom are of school age (Central Statistics Office, 2016b)

With funding from the National Council for the Blind in Ireland (NCBI) a blind researcher worked with the ABAIR team to develop the NVDA screenreader plugin. It additionally provides simultaneous Braille output from the opensource Liblouis Braille translator[2] which has features that support screenreading programmes such as the NVDA system. The user chooses the 'speaker' (male or female) and controls for the speed of the spoken output. Note that very high speeds are often used for browsing by proficient readers, whereas young learners might need quite slow reading speeds. For those with some partial vision, text is highlighted and magnified as it is read out. Beyond the educational context, the screenreader allows the user to fully participate in the digital world, communicate with the lively online language community, keep up with current affairsas well as read, write and edit documents. The system was extensively tested with visually-impaired school children and a full technical description is available in McGuirk (2005).

5 Technology for those with dyslexia

The provision of a screenreader was primarily a matter of building an interface that would allow access to the ABAIR voices and facilities. In other areas, assistive technologies require in-depth

[2] www.liblouis.org

knowledge of the language structure and, in a given bilingual context, a knowledge of how the structure of the minority and major language differ. This linguistic knowledge supports the development of more effective solutions to challenges that may arise. Such is the case in the provision of applications for those with dyslexia, the most frequently reported additional educational need in Irish immersion schools (Nic Aindriú, Ó Duibhir & Travers, 2020). Assistance with Irish literacy teaching and training for pupils with dyslexia is frequently requested by teachers in Gaeltacht and Irish-medium schools. Tackling this issue involves much more than a technology interface - it requires much basic research to identify issues and build the additional linguistic resources needed to address them.

Phonemic awareness (an explicit awareness of the sound structure of the language; Goswami & Bryant, 1991), and an understanding of phonic rules (how sounds map to letters) have a key role in literacy acquisition, and often form a key part of dyslexia assessments and interventions.

Irish and English are very different in both (i) the phonemic sound systems and (ii) orthographic systems. This means that children need to learn two separate systems, one for each language. The most distinctive feature of Irish phonology is the set of velarised-palatalised consonant contrasts.

	Initial palatalised consonant	Orthographic transcription	Initial velarised consonant	Orthographic transcription
Front vowel	bʲi:	bí	bˠi:	buí
Back vowel	bʲo:	beo	bˠo:	bó

Figure 2: Phonological and Orthographic representations of an initial pair of velarised-palatalised consonants followed by (phonologically) front and back vowels.

This sound contrast is represented opaquely in the orthography, as the Latin alphabet does not allow for an effective doubling of consonantal letters. Thus, for a minimal pair like [lʲo:nˠ] *leon* 'lion' and [lˠo:nˠ] *lón* 'lunch' the same initial letter "l" is used to for the contrasting palatalised and velarised initial consonants. The quality difference is signalled by the nearest vowel letter. An adjacent "i" and "e" (front vowels) signal a palatalised consonant, while an adjacent "u", "o" and "ɑ" (back vowels) point to a velarised consonant. (See Figure 2). To sum up, the consonantal contrast is not overtly marked, and vowel letters can have different functions: they may represent an actual phoneme, or they may serve to denote the quality of an adjacent consonant (see Ní Chasaide, 1999).

This opaque representation of the sounds can be challenging for readers but is particularly challenging for those with dyslexia. Learners are largely not consciously aware of the consonantal contrast. Children outside of Gaeltacht areas often have little exposure to native speaker speech and may not acquire the sound contrasts which are important for understanding the writing system. The fact that all pupils are taught the phonics of English further impacts on their grasp of the sound and phonic systems of Irish.

Figure 3: Homepage of the Lón don Leon platform.

There is a dearth of resources for children with dyslexia in Irish. As the first step in tackling this question an interactive platform has been developed to train phonological awareness and early phonics skills. This platform, *Lón don Leon* 'Lunch for the Lion' is set on an imaginary Aran Island (see homepage in Figure 3), populated by characters and objects (like the lion and his lunch) which provide minimal pairs that illustrate the contrast. Specially written stories with graphics, musical ditties and quizzes aim to consolidate phonological awareness and memorisation of contrasts. When the phonological contrasts are acquired, further games make explicit how these sounds map to the orthographic letters.

The platform uses a mixture of prerecorded (songs and stories) and the ABAIR synthetic voices (in spelling activities). It is being presented as a learning platform for all – but is particularly critical for those with dyslexia. Having the synthetic voices is particularly helpful, as it brings the native speaker right into the classroom. The platform draws on previous linguistic and educational

research (Ní Chasaide 1979, 1999; Barnes, 2017, 2021), and the hope is to launch it later this year.

In its current form, *Lón don Leon* is focussed on training and intervention. However, we envisage in the future that it will be extended to incorporate assessment materials that will address the dearth of screening and diagnostic assessments for dyslexia (Barnes 2017; Nic Aindriú, Ó Duibhir & Travers, 2021). Additional support materials for pupils with dyslexia and their teachers are also envisaged.

The development of *Lón don Leon* and its underpinning research has benefitted from extensive interaction with stakeholders (interviews with educational psychologists, discussions with educational professionals, testing with children and consultation with Irish language organisations).

6 Speech enabled AAC

A speech-generating AAC system allows the non-speaking user to select a series of images/words which are subsequently spoken aloud by the computer. Though many such systems exist for the English language, there is currently no such system available for Irish. As shown in a recent survey (Nic Corcráin, 2021) many people could benefit from such a system, including autistic people, as well as people with Cerebral Palsy, Parkinson's Disease, Alzheimer's disease and those with learning disabilities (Enderby et al, 2013).

There are many autistic children who attend and benefit from Irish immersion schools (Nic Aindriú, Ó Duibhir & Travers, 2020). The lack of a speech-generating AAC system in Irish means that non-speaking autistic children and children with communication disabilities are excluded de facto from fully participating in their language community, whether in the Gaeltacht or in Irish immersion schooling. There is an urgent need to develop such a system to remove the barriers preventing children from fully participating in school and in their communities, as well as from accessing their rich linguistic and cultural heritage. An Irish prototype AAC system has been developed within the open-source Coughdrop system. The bilingual context of users, and the linguistic structural features of Irish have a considerable impact on how AAC can be developed, as beyond the phonological and orthographic differences between Irish and English mentioned above, there are major differences in morphology, syntax and semantics. Irish is an inflected language: nouns and adjectives have a number of cases; there are numerous inflections of verbal forms; many classes of content words undergo initial mutations (alternation of the initial consonant in specific grammatical contexts – a feature of all Celtic languages). This means that content words have a large number of forms (written and spoken) when compared to English. For example, the word 'house' has just two forms in English (house, houses); in Irish it has many more (*teach, tí, tithe, theach, dteach, thithe, dtithe*). In the case of numerals there are different forms: for example, the word for 'two' may emerge as *dó, dhá, beirt, dhó* depending on the subject (human/non-human) and the grammatical context.

Differences also exist in the semantic domains of superficially cognate words such as 'know'. In English, there is a single term for knowing a person, a fact, a subject, a language, and a place. In Irish there are different terms depending on the object of the sentence (e.g., *aithne, ar eolas, fios/a fhios*). This makes it challenging to graft an Irish system into an existing English- schema.

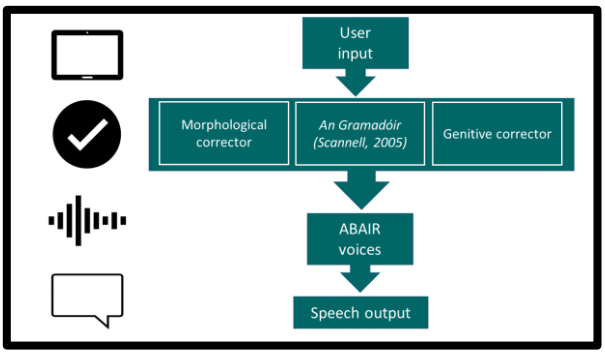

Figure 4: A schematic representation of the Irish AAC system currently under development

As a way of going from a sequence of images to a sentence with a correct grammatical form, the system currently under development uses three grammar checkers and correctors: (1) a morphological corrector based on hand-coded grammatical rules provides corrections for certain inflected forms; then the input is processed by (2) an open-source grammar checking engine *An Gramadóir,* built using language-independent software for under-resourced languages (Scannell, 2005), and finally (3) a genitive checker corrects nouns in the genitive case. As illustrated in Figure 4, the user inputs a string of symbols with their associated root lexical forms into the Coughdrop system. The lexical string is then sent to the AAC API, which allows for grammatical correction by

the three correctors described above. The corrected version is then sent to the ABAIR TTS API, and the sound files generated are returned to the Coughdrop system as spoken output. Again, the user chooses the dialect, the speaker and the speed.

The bilingual context in which the system will be used provides further challenges that have a bearing on the system design. Speech output from AAC devices involves using motor sequences to select items. Therefore, it is aided by visuo-spatial representations rather than phonological (sound-based) ones (Dukhovny & Gahl, 2014). When using such devices, people remember and access words through motor plans, as they do when typing (Dukhovny & Gahl, 2014). More research and on-the-ground testing will be needed to establish whether one should aim to optimise the layout of symbols in order to optimise the motor plans in both Irish and English. In practice, this would mean maintaining consistency in the positions of the buttons in each language version of the AAC system. These are still open questions that require research and ongoing evaluation with users.

As with the other developments discussed here, the strong initial impetus for this project came from the community. Speech therapists working with non-speaking clients have been requesting Irish AAC, and a kickstart was provided in an urgent request by a parent whose children require such a system and who wanted to work with us to develop one. Her children need Irish AAC in order to fully access the curriculum in their Irish-medium school, as well as to communicate with their Gaeltacht-based family members and friends. More recently this parent has joined the research team.

7 Conclusions

Developing assistive technologies for an endangered/minority language involves a great deal more than interfacing and simple translation. An understanding of the language structure is critical to many of the technologies, and the bilingual context in which the users use the technologies can have important implications on how we design them. For example, the AAC system might require differences in design depending on whether the users of Irish are L1 or L2. In the case of devices for developing phonological awareness and early literacy training, the L1-L2 differences are the key basis for the system design. Other linguistic factors such as the great diversity of dialects, and the lack of a single spoken standard, is something that is likely to occur in many endangered languages.

One advantage of the current developments for Irish is that the core technologies are being developed in parallel with the applications described here. This means that the priorities in the core developments are guided by an understanding of the needs of the potential end users. While the dialect diversity is currently catered for with our Irish synthetic voices, the provision for children's voices (for the various dialects) is being targeted for future research given how necessary it is for many of the users, both in the disability and educational spheres. These same considerations are central to the current and future development of automatic speech recognition for Irish. Our current prototype has been optimised for native speaker adults of the different dialects and extending this to children's speech will be the important next step.

From the above it is clear that a multidisciplinary team is ideally required involving researchers who not only have the prerequisite technical skills but also a deep understanding of the structure of Irish, allied to an understanding of the bilingual and social context. Finding skilled interdisciplinary researchers has proven to date to be the greatest challenge to ABAIR's progress.

In developing assistive technologies, it is important to work with existing open-source systems where such are available. As a guiding principal, ABAIR aims to ensure that the outputs are cost-free and made readily available on the ABAIR website.

The language community and the network of end users for particular disability applications have been central to the developments discussed here. Ultimately, the user and the user's support networks (teachers, family, carers, therapists) have had a role – not as passive recipients of ready-made prototypes but rather as active partners from the outset with input into every stage of development from design to implementation, evaluation and dissemination.

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