A COMPARISON OF IRISH AND ENGLISH LANGUAGE FEATURES AND THE POTENTIAL IMPACT ON MATHEMATICAL PROCESSING

Máire Ní Ríordáin

National University of Ireland, Galway, Ireland

This paper presents some insights into the syntactical and semantic differences between Irish and English, and the potential impact on mathematical processing. Previous research suggests that learning mathematics through the medium of Irish at primary level education may enhance mathematical understanding (Ní Ríordáin, 2011; Gilleece, Shiel, Clerkin & Millar, 2011). A key question being addressed here is do characteristics of the Irish language potentially have a different effect on students' mathematical processing of text. No examination has been undertaken on the Irish language and its potential impact on cognitive processing – this initial analysis is striving to provide some useful insights for further investigation.

INTRODUCTION

Recent studies conducted in Ireland into Irish-medium education have demonstrated positive cognitive advantages in relation to mathematical and English reading attainment in comparison to students who attend all-English medium education (Ní Ríordáin, 2011; Gilleece, Shiel, Clerkin, & Millar, 2011). These investigations accentuate the positive benefits that can be reaped from being bilingual and are consistent with international findings in relation to the benefits of bilingual and immersion education (e.g. Bourton-Trites & Reeder, 20001; Genessee, 1987; Turnbull, Hart, & Lapkin, 2000). For Gaeilgeoirí (students who learn through the medium of Irish) in the transition from primary (Irish-medium) to second level (English-medium) mathematics education a significant relationship exists between their performance on the mathematical word problems through the medium of English and their Irish language proficiency (Ní Ríordáin, 2011). Gaeilgeoirí with high proficiency in both languages, and those who were dominant in Irish, performed mathematically better than their monolingual peers. This suggests that learning mathematics through the medium of Irish at primary level education may enhance mathematical understanding. A recommendation arising from the study was to review the Irish language with respect to the effect on the understanding and processing of mathematical text. This paper presents an initial analysis of the Irish language and its differences with the English language in relation to some grammatical features.

THE ROLE OF LANGUAGE IN MATHEMATICS

Language and communication are essential elements of learning and teaching mathematics (Gorgorió & Planas, 2001) and thus the language we initially learn

mathematics through will provide the foundations to be built upon and developed within that language. Language is employed as a communication tool and facilitates the transmission of (mathematical) knowledge. We consider mathematical language as a distinct 'register' within a natural language e.g. Gaeilge or English, which is described as "a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings." (Halliday, 1975, p.65). Each language will have its own distinct mathematics register and ways in which mathematical meaning is expressed in that language.

Vygotsky was one of the earliest theorists to begin researching the area of learning and its association with language. He concluded that language is inextricably linked with thought – '..the concept does not attain to individual and independent life until it had found a distinct linguistic embodiment.' (Vygotsky, 1962, p. 4). Although a thought comes to life in external speech, in inner speech energy is focused on words to facilitate the generation of a thought. If this is the case, it raises an important question – does the nature of the language used affect the nature of the thought processes themselves? The transition from thought to language is complex as thought has its own structure. It is not an automatic process and thought only comes into being through meaning and fulfils itself in words. Thought is mediated both externally by signs and internally by word meanings (Vygotsky, 1962). Communication is only achieved by the thought first passing through meanings and then through words. Therefore, language will play a significant role in the processing of mathematical text and the development of understanding (Hoosain, 1991).

Mathematics is not "language free" and due to its particular vocabulary, syntax and discourse it can cause problems for students learning and the development of understanding (Barton & Neville-Barton, 2003). A number of mathematics education researchers have identified characteristics of the English language that may impede mathematical learning (e.g. Austin & Howson, 1979; Durkin & Shire, 1991; Rudner, 1978; Wareham, 1993). In her review article, Galligan (2001) highlights the differences between Chinese and English in terms of vocabulary, word-order, use of prepositions and other grammatical features, and their impact on the understanding and processing of mathematical word problems. It raises the question of whether the language of learning impacts on mathematical ability and the processing of text. Other studies have highlighted a Chinese language advantage in relation to number sense (Fuson & Kwong, 1991), fractions (Bell, 1995) and logical connectives (Zepp, Monin, & Lei, 1987). It is important to note that when comparing mathematics processing in different languages and across different cultures, that there are many factors to consider e.g. social, political or pedagogical differences (Setati & Planas, 2012). However, what is of concern to the author is whether the Irish language potentially has a different effect on student attainment in mathematics. As Barton (2008, p. 11) states 'languages are examined not so much for their linguistic characteristics, but for their mathematical ones.' No examination has been undertaken on the Irish language and its potential impact on mathematical cognitive processing –

this initial analysis is striving to provide some useful *insights* for further investigation and some explanations for previous findings within the Irish context.

DEVELOPMENT OF THE RESEARCH

The research undertaken stems from the author's PhD studies (Ní Ríordáin, 2011). In this study the relationship between mathematics and language proficiency in Irish/English was examined, with psycholinguistic theories informing research practices. The findings provide support for Cummins Threshold Hypothesis in that Gaeilgeoirí with a high proficiency in both languages performed mathematically better than those dominant in one language and better than their monolingual peers. Gaeilgeoirí with low proficiency in both languages were the weakest mathematically also. At second level education high competence in Irish was shown to facilitate the transition to English medium education (Ní Ríordáin & O' Donoghue, 2009). The other dimensions of language investigated included the particular language features of the English mathematics register that cause problems for Gaeilgeoirí. At both transitions it was found that Gaeilgeoirí encounter difficulties with the syntax, semantics and mathematics vocabulary of the English mathematics register (Ní Ríordáin & O' Donoghue, 2011). Clearly, the research generated the need for further investigation into the Irish language and its potential impact upon mathematical learning and processing.

More recent research investigating a bilingual approach (English and Irish) in third level mathematics education in Ireland, demonstrates that on average bilingual students performed better mathematically than those choosing a monolingual approach (Ní Ríordáin & McCluckey, 2012). Those opting for a bilingual approach at third level employed both languages for arithmetic computation and problem solving. Reverting to the use of Irish tended to relate to previous experiences, perceived difficulty and for affective reasons. Clearly, Irish is still of importance in mathematical computation and problem solving when transitioning to English-medium third level education. The knowledge and understanding that both languages play a role can provide insights into bilingual students' mathematical thinking (Clarkson, 2007). The studies undertaken by the author suggests that there are advantages associated with having two languages (Irish and English) for mathematics learning, and that learning mathematics through the Irish language may lead to cognitive advantages for these students. Therefore, this study goes some way in identifying some of the potential advantages that these students may experience by utilising Irish when engaged in mathematical problem solving.

The list of differences between Irish and English are the consequences of a bibliographical review on several works around learning mathematics and language use. In particular, studies addressing mathematical processing in English (e.g. Austin & Howson, 1979; Galligan, 2001; Li & Thompson, 1981, Wareham, 1993) were of significance, as well as studies highlighting the key characteristics of the Irish language (e.g. Hickey, 1985; Mac Murchú, 1997). By utilising these studies it provided the author with a foundation and framework for progressing with an initial

analysis of the Irish mathematics register and its potential impact upon mathematical processing.

DIFFERENCES BETWEEN IRISH AND ENGLISH

This section provides an overview of some of the key differences between the Irish and English languages, drawing on previous research. A comparison is undertaken in terms of some of the key features associated with the syntax and semantics of both languages.

Subordinate clauses and sentence length

In modern Irish, longer sentences are common, with the use of subordinate clauses. However, in many of the mathematical examples studied in current textbooks and state examination papers, shorter sentences are apparent. For example:

> *Tá poll in aice leis an mbun in umar sorcóireach oscailte d'uisce. Is é ga an umair ná 52cm.*
>
> Translation (T): There is hole near bottom in tank cylindrical open of water. It is radius of the tank 52cm.
>
> English (E): An open cylindrical tank of water has a hole near the bottom, with a radius of 52cm.

Shorter sentences lend to an easier understanding of mathematical text and are a desirable feature (Austin & Howson, 1979; Wareham, 1993).

Topic prominence

English is classified as a subject prominent language (Li & Thompson, 1981), whereas Irish tends to be a topic prominent language. For example:

> *Is slánuimhir é ceann amháin de na luachanna sin*.
>
> T: It integer is one of the values these.
>
> E: One of these values is an integer.

In this example the Irish reader's attention is drawn to the *integer*, whereas the English reader is drawn to the *value*. Therefore, the Irish reader is pointed to the topic of the sentence (Galligan, 2001).

Word order

Irish possesses the unusual word order Verb (V) – Subject (S) – Object (O), whereas English is classified as SVO (Galligan, 2001). For example:

> *Faigh comhordanáidí an dá phointe ina dtrasnaíonn na cuair $y = f(x)$ agus $y = g(x)$ a chéile.*
>
> T: Find coordinates the two points intersect the curves $y = f(x)$ and $y = g(x)$ each other

E: Find the coordinates of the two points where the curves $y = f(x)$ and $y = g(x)$ intersect.

The placing of information and the unknown in sentences may have an impact on the ease of processing the sentence (Galligan, 2001; MacGregor, 1993). From the above example, English readers have a greater cognitive processing load in that they must hold in memory *co-ordinates of the two points* before reading the words *curves...intersect*. Whereas Irish readers are drawn to the key information of the sentence and this suggests a difference in mathematical processing in Irish.

Question structure

Irish has no words for "yes" and "no". The answer to a question contains a repetition of the verb, either with or without a negative particle (Hickey, 1985). For example:

An éisteann Seán lena mháthair riamh? - "Does Seán ever listen to his mother?"

- *Éisteann* - "Yes , he does"
- *Ní éisteann* – "No, he doesn't"

In Irish, the question word tends to be placed at the start of a mathematical sentence and the syntactic structure is much simpler when compared to English. According to Galligan (2001, p.117) 'English question structure is more varied, and the change from the question to the answer requires changes to word structure and verb morphology.'

Passive voice

Irish commonly uses the impersonal form (also known as the autonomous form) instead of the passive voice. For example:

Líonadh an umar le h-uisce.

T: One filled the tank with water.

E: Someone filled the tank with water/The tank was filled with water.

The word endings 'adh'/'eadh' are used to indicate the passive (Mac Murchú, 1997), and therefore provides students with a strong cue when engaged in mathematical problem solving. English mathematical word problems have been criticised for difficult passive constructions (see Slobin, 1973 – reversible sentences), thus impacting the processing of mathematical text.

Redundancy

Rudner (1978) found that inferential and low information pronouns are sources of difficulty and hinder students' interpretation and understanding of English mathematical word problems. Mathematical text in Irish tends to be more wordy, thus impacting on reading time, but understanding may be clearer (Galligan, 2001). For example:

Cé mhéad soicind a bheidh caite nuair a bheidh aired 64cm ag an dromchla?

T: How many seconds will have passed when height 64cm has surface?

E: After how many seconds will it be a height of 64cm?

Dialects

There are three dialects of spoken Irish – Munster, Connacht and Ulster. Some spelling conventions are common to all the dialects, while others vary from dialect to dialect (Mac Murchú, 1997). In addition, individual words may have in any given dialect a pronunciation that is not reflected by the spelling. Therefore, Irish can be a difficult language to interpret due to variation. Accordingly Irish students may need to engage more with a written mathematical problem due to the diverse nature of the Irish language. Consequently Gaeilgeoirí may develop stronger mathematical problem skills relating to comprehension and transformation.

Alphabet

The Irish alphabet consists of (Mac Murchú, 1997):

- Vowels **a, e, i, o, u**

  With an acute accent (sineadh fada) shows the length of the vowel **á, é, í, ó, ú**

- Consonants **b, c, d, f, g, h, l, m, n, p, r, s, t**

  The constant **h** serves as a notation lenition (bh, ch, dh, etc.) and as the h-prefix (ha, he, etc.).

Given that there are fewer characters used to write Irish, the meanings are more variable and hence context is more important when dealing with mathematical text.

Access to meaning

Orthography plays a key role in reading and processing mathematical text (Galligan, 2001). The nature of some of the Irish mathematics vocabulary allows readers to access the direct meaning of the words. For example, the word in Irish for velocity is ‘treoluas’ (direction speed) and parallel is ‘comhthreomhar’ (equal directionality). Many of the Irish words describe concepts/objects as opposed to just labelling them. Given that the more easily and quickly the meaning of words is activated, the simpler it is to process mathematical text. Also, it may help to retrieve all the words associated with the concept thus enhancing the total cognitive structure (Galligan, 2001).

DISCUSSION

This initial comparison of the Irish and English language demonstrates that there are differences between the two languages. However, what is difficult to interpret is whether differences between the languages have a differential impact upon cognitive processing (Galligan, 2001). The syntactical structure of the Irish language in terms of sentence length, topical prominence and word order, appears to lend itself to easier

interpretation of mathematical meaning in comparison to English. Accordingly, Irish may lend itself to easier mathematical word problem solving and the acquisition of enhanced processing skills. In particular it raises the question of whether Gaeilgeoirí have faster and more accurate access to mathematical text and accordingly strategies for arriving at a solution.

A significant insight from the analysis is that some Irish words assist in conveying meaning and/or permit the concept to be formed more readily. Similarly the sentence structure allows access to key information. Given that Irish readers are drawn to the key information of the sentence, and that this suggests a difference in mathematical processing in Irish, these surface features may aid mathematical problem solving, while providing a support for developing a deeper understanding of the word problem.

Similarly, context plays a key role in mathematics and in the interpretation of mathematical text. Given that the meanings are more variable in Irish and hence context is more important when dealing with mathematical text, this may lend to the development of better mathematical problem solving skills for Gaeilgeoirí. In particular, the author would suggest that it may lead to Gaeilgeoirí 'reading more carefully and accurately because they have to rely on context more' (Galligan, 2001, p.126).

When comparing English and Irish, visually they do not appear to be significantly different. However, the syntax and semantics of a language plays a crucial role in interpreting mathematical text and developing meaning (Galligan, 2001). A key question arising from this analysis is do students who learn through the medium of Irish employ different processing strategies when interpreting mathematical text, and consequently does this impact on mathematical attainment and understanding?

The author proposes that proficiency in Irish and experience of learning mathematics through Irish may lead to cognitive advantages and enhanced processing of mathematical text (as outlined in previous sections) and accordingly may contribute to the development of this additive bilingualism. Additive bilingualism results when a second language and culture have been acquired without loss or displacement of an individual's first language and culture, and a positive self-concept is correlated with this form of bilingualism (Baker, 1996). However, subtractive bilingualism results when an individual's first language and culture are replaced by the new language and culture, usually occurring in a pressurised environment. As a consequence a negative self-concept may develop due to loss of culture and identity (Baker, 1996). Within the Irish context additive bilingualism is fostered through Immersion (Irish-medium) education at both primary and post-primary levels (Ní Ríordáin, 2011). High ability Irish bilingual students (additive bilingualism) display an enhanced meta-cognitive ability demonstrating flexibility in thinking and reasoning, self-correction, and an ability to select appropriate features for problem solving (Ní Ríordáin & McCluskey, 2012). This reinforces the point that bilingualism in Irish and English has the

potential to enhance mathematical teaching and learning, while doing mathematics through the medium of Irish may contribute to enhanced mathematical processing.

CONCLUSION

This paper presents an initial analysis of the comparison between Irish and English language and its potential impact on mathematical processing. Some promising insights are emerging, suggesting that students who learn through the medium of Irish may experience advantages in terms of processing mathematical text. Clearly further research is warranted in this area. In particular, further investigation is needed into whether Irish language processing strategies have an impact on the way Gaeilgeoirí understand mathematical text and solve mathematical word problems. Moreover, do these processing skills transfer to a new language of learning and to the development of additive bilingualism? Similarly, research into whether characteristics of the Irish language potentially have a different effect on student attainment in mathematics would be valuable. An in-depth study into the nature of the Irish language could contribute to significant insights into the cognitive benefits reaped from being bilingual (Ní Ríordáin, 2011).

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