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Final Report

Product Performance Data Analysis - IDL

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Careers | Lancaster University

boost
Lancashire's Business Growth Hub

Ascentis AO Internal Report

IDL intervention analysis and perspectives based on data from 2011 to 2018

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1. Introduction

In this report I will analyse data from IDL (Indirect Dyslexia Learning), a "cloud-based intervention software that has been specifically designed for 'people' with dyslexia and dyslexic type tendencies" (Ascentis-1, 2018). Ascentis, an awarding organization based in Lancaster (UK), owns this software and maintains its development (Ascentis-2, 2018). In this regard, previous analyses of IDL intervention[1] efficacy have shown very positive results. For example, one research conducted on a sample of 150 subjects (children and adults) has shown that the use of IDL produces, on average, reading and spelling related improvements 4 times better than other forms of intervention (Scrase, 2002). Another, more recent research has involved about 700 beneficiaries and has confirmed that IDL produces significantly faster reading and spelling related improvements than "non-specialist teaching methods" (Lifting Barrier Project, 2014).

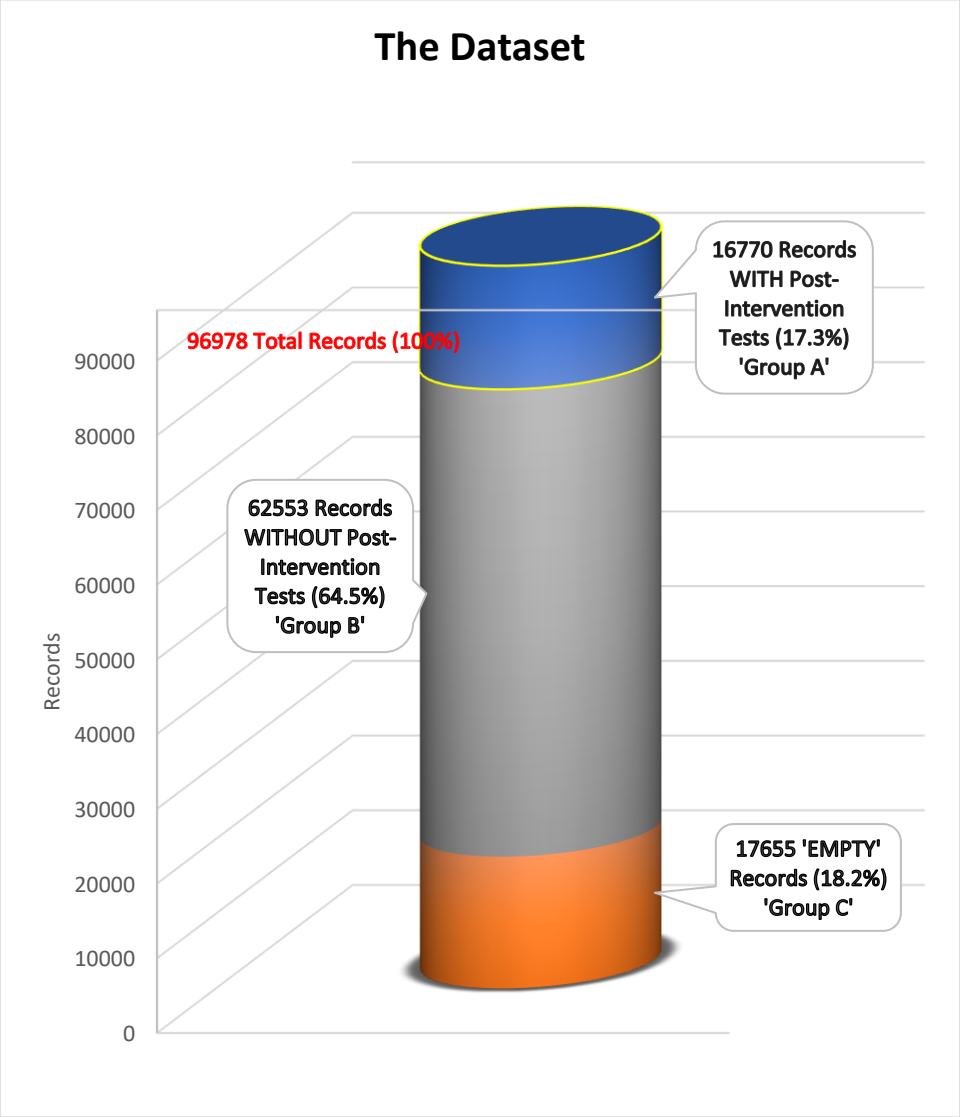
As regards my analysis, I will also examine the efficacy of IDL intervention, but my study will be different than previous pieces of research.
On the one hand, the previous research is based on data related to uniform and strictly controlled IDL training sessions, and on a small number of subjects of which it was possible to collect many details (for example: dyslexia type, improvements in confidence and self-esteem).
On the other hand, my set of data is larger, has less details, and represents a more 'operative' context with very varied forms of IDL interventions (for example, in terms of lesson frequency and overall intervention duration) and sometimes with evident errors in data reporting (for example, starting dates that follow ending dates).
The operative context of this study, as opposed to the controlled 'test' environments of the previous research, will be useful to confirm or correct previous findings, to control the robustness and adaptability of IDL applications, and possibly to suggest further improvements.

2. The Dataset

2.1 Introduction

This study is based on a data repository that contains 96978 records. Each of these represents a single IDL intervention. However, 17655 records (Group C) of this lot are 'empty' registrations (they just contain subject[2] and school data without any intervention data). Moreover, only 16770[3] records (Group A), of the remaining 79323, include post-intervention test data (data that represent reading and spelling improvements following a period of IDL intervention). Thus, although most of the records (62522 Group B) contain some IDL intervention data, they do not allow an analysis of the efficacy of the intervention.

[1] In this document the terms 'intervention' and 'application' mean: literacy training based on IDL
[2] Group C subjects are not under IDL intervention
[3] 16773 records if we also consider 3 more records with 0 and 1 'New lessons'.



In my analysis I will completely exclude Group C because it does not contain any useful data.

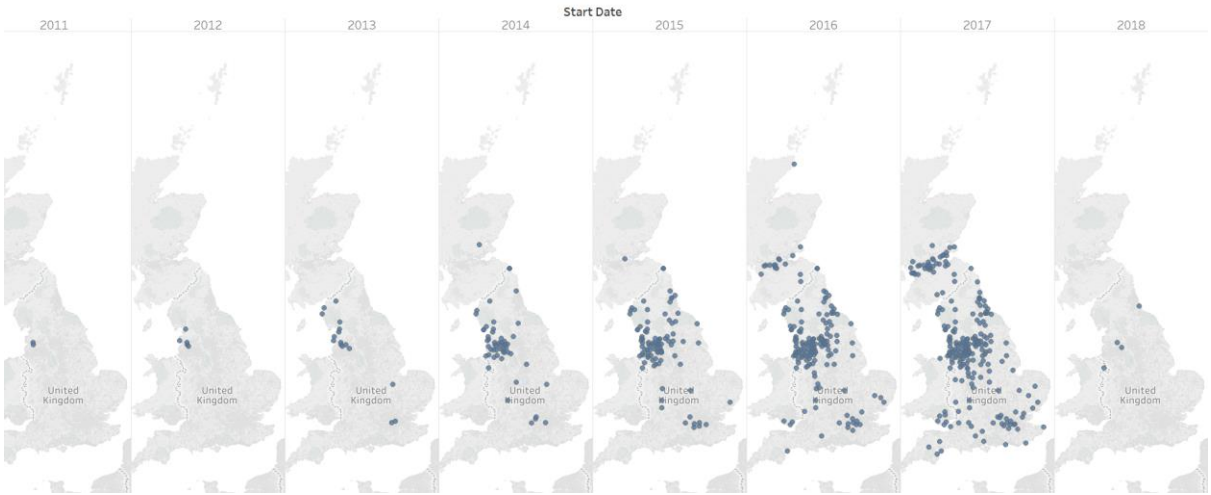
As regards Group B I will analyse its 'demography' (variables such as: age, intervention start date, gender, city, students number) separately and in conjunction with 'Group A'. Indeed, this group represents subjects who are currently involved in IDL training programmes.

Finally, I will analyse the data contained in Group A in detail. This last group that represents completed IDL interventions[4] is the most important as it allows an evaluation of the efficacy of IDL intervention.

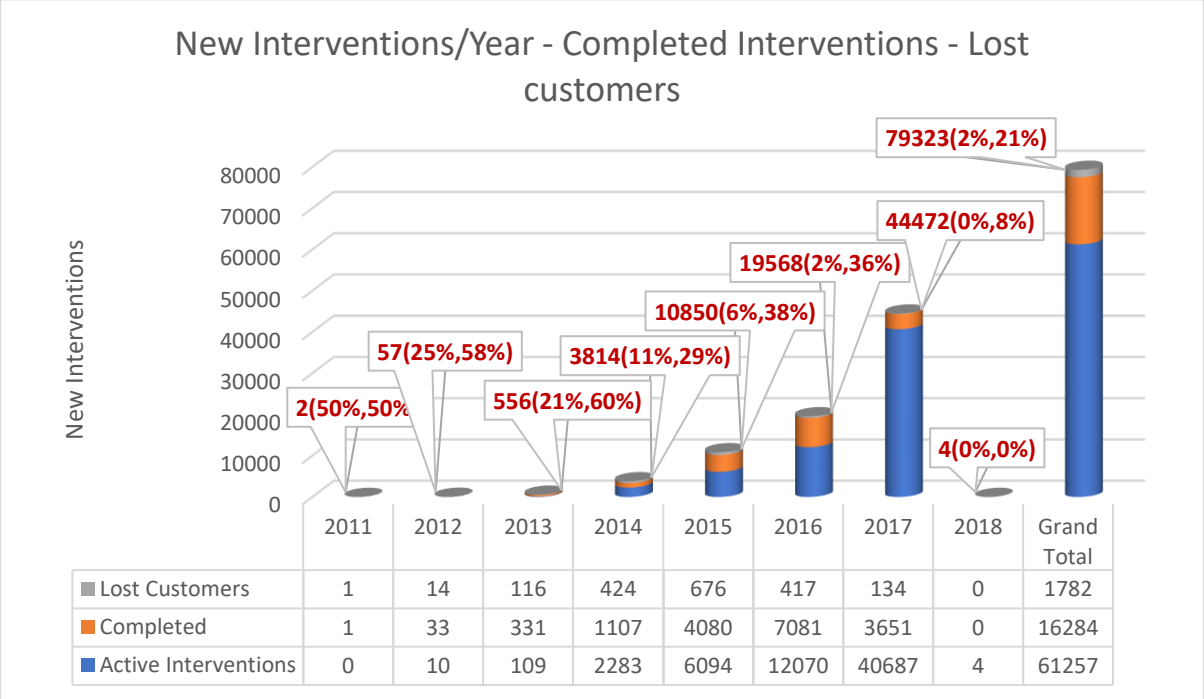
[4] Only three records have not an 'end date' but show a measure of post-intervention performance.

2.2 Number of interventions

The following image shows a fast-growing use of IDL. In this regard, blue points on the UK map show cities where IDL is currently adopted. As we can see, there is an important and constant increase in the number of cities from 2011 to 2017. The map of 2018 shows few cities because our data is updated only to the first days of this year.



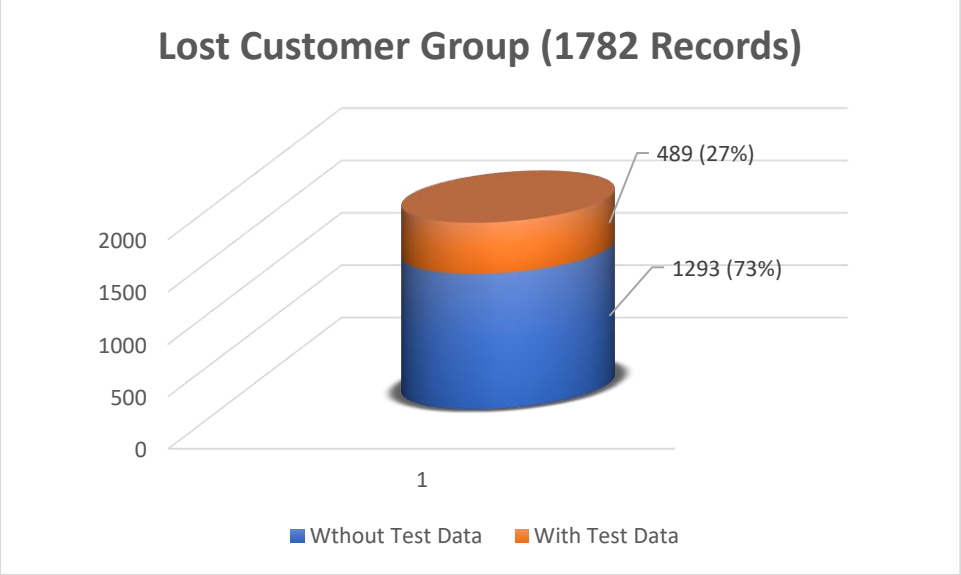
The following graph shows the number of new IDL interventions for each year:



	2011	2012	2013	2014	2015	2016	2017	2018	Grand Total
Lost Customers	1	14	116	424	676	417	134	0	1782
Completed	1	33	331	1107	4080	7081	3651	0	16284
Active Interventions	0	10	109	2283	6094	12070	40687	4	61257

In the above chart, the total number of new (non-cumulative) interventions is in red[5]. Beside this figure, firstly, there is the percentage of lost customers, secondly, the percentage of completed interventions.
As we can see, there is an important increase in the number of active interventions[6] (blue column parts). Lost customers are represented by grey (top) column parts. Orange parts show the number of completed interventions.
This chart alone shows the success of IDL and anticipates its positive performance analysis. Indeed, customers would not probably use a product/service if it was not effective.
Moreover, the above figures represent the need for new/additional management resources. Indeed, the training/commercial management of few tens of interventions of the first years are certainly much less demanding than the current number of active interventions (61257 records).

2.2.1 Lost customers group details



If we go into the details of the 'lost customers' group (1782 records) we can see that only a small lot of its records contains post intervention test data (489 Records, 27%). Thus, IDL performance cannot be blamed for the premature ending of these interventions, at least in most of the cases. There are other reasons for these desertions or, given their small percentage value (2% of total new interventions), they represent 'physiological' negativities.

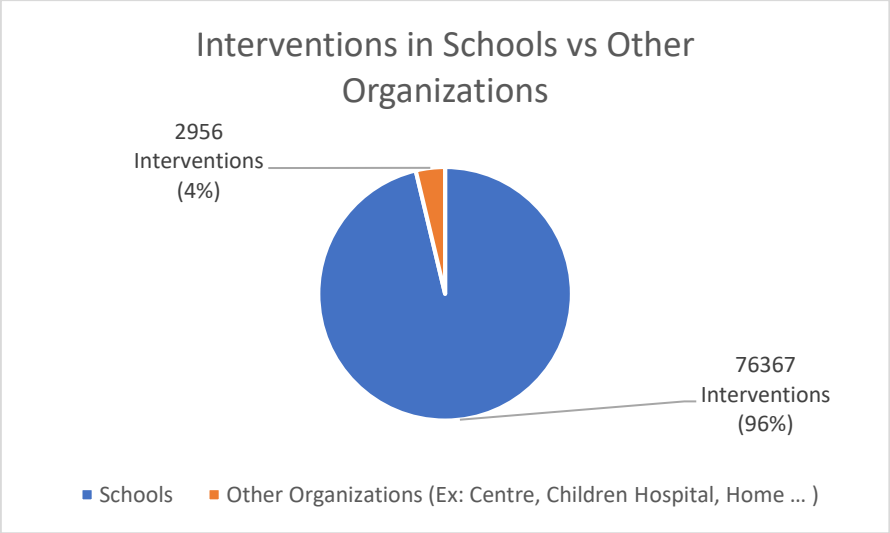
2.3 Customer Characteristics

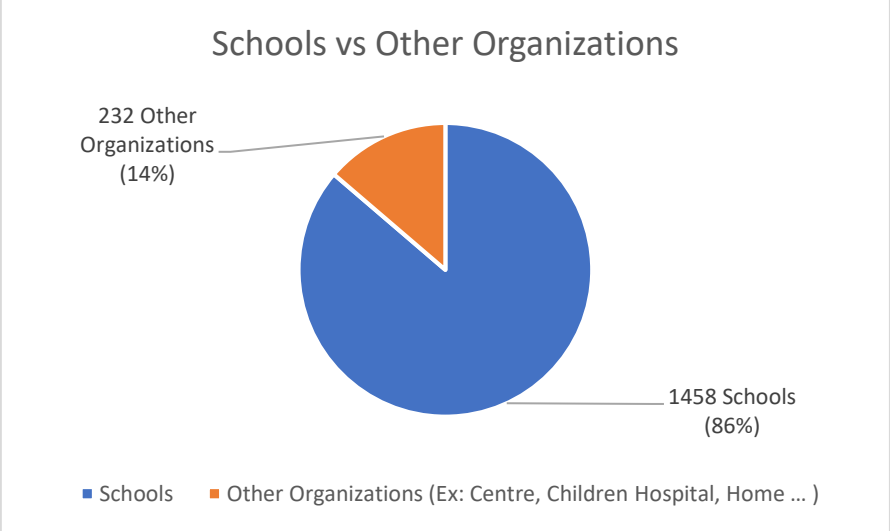
In the context of this report, the term 'customer' has a twofold meaning.
On the one hand, it signifies each child or adult (learners/trainees) who has started a period of IDL intervention. In this regard, I will later describe their gender and age characteristics.
On the other hand, customers for Ascentis are very often represented by schools or other organizations/institutions such as councils or hospitals where, or by means of, children and adults receive their IDL intervention. These 'customer groups' are the main object of Ascentis' commercial

[5] Not cumulative. Only cumulative in the last column (Grand Total)
[6] Not cumulated new interventions minus lost customers and completed interventions.

management. Indeed, in most of the cases, children and adults (or their families) do not directly choose their dyslexia-related training. The latter is determined by the institution/organization they are part of. In our dataset, a proxy of these 'customer groups' are postcodes.

As we can see from the following pie-charts, most customer groups are schools[7].

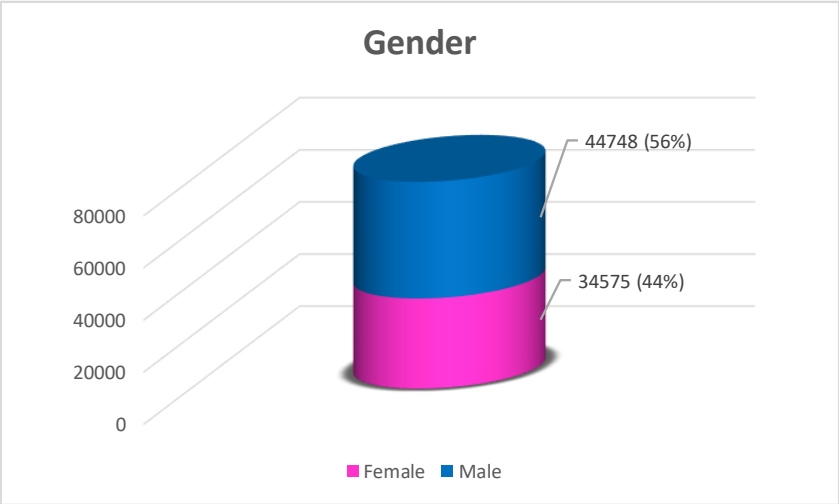




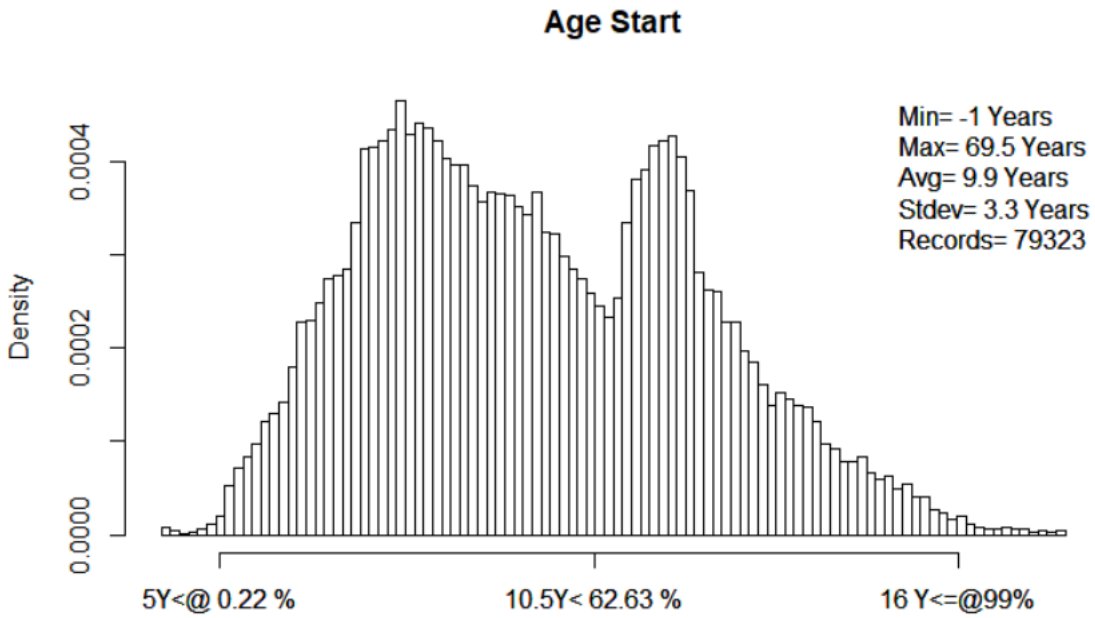
[7] This is an approximation. The number of schools is probably higher than that shown in the graph because some 'customer groups' are marked as "lost customer" or "trial" without specifying their nature.

2.3.1 IDL Trainees by Gender and Age

The following charts describe gender and age characteristics of IDL trainees:



The above chart shows a majority of male trainees (56%).

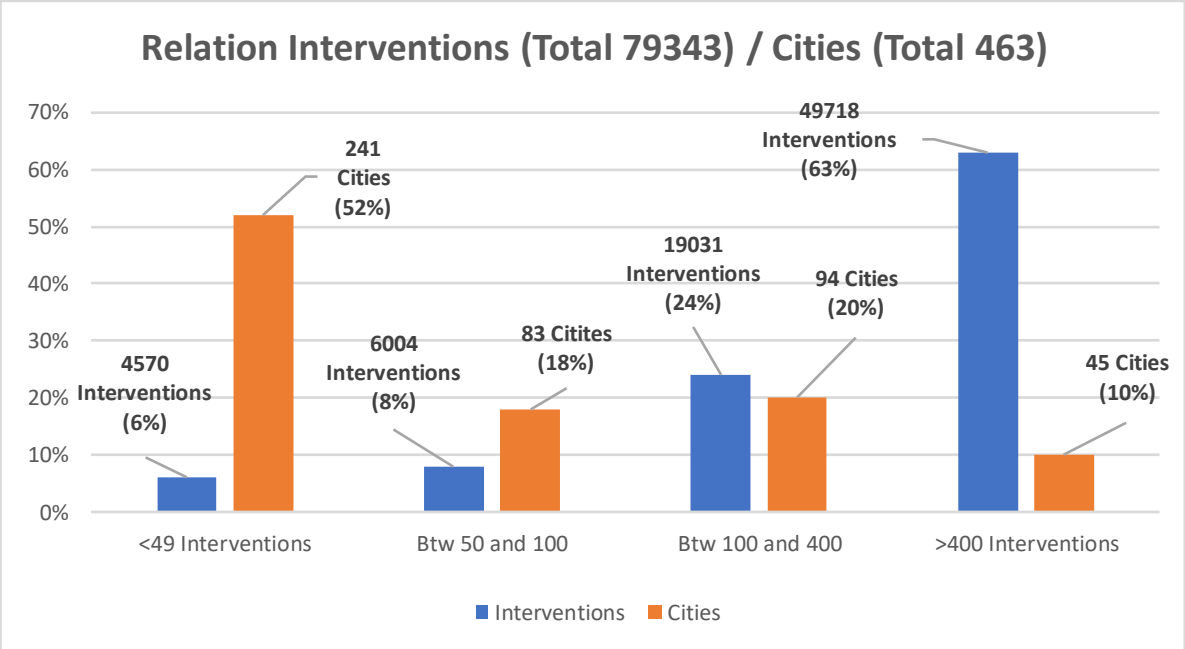


The above chart shows the age distribution of children and adults at the start of their IDL intervention. As we can see the curve has two peaks and is approximatively 'divided' by the point that separates the Key Stages 2 and 3 of the UK national curriculum (11 years) (BBC, 2015). The minimum age is "-1", evidently, because a small number of records is not correctly reported. Moreover, only 0.22% of the trainees are less than 5 years old, and most of the them (99%) are less than 16 years old. Finally, there is a majority of key stage 2 trainees (63%).

2.3.2 IDL Trainees/Interventions by cities and postcodes

The following charts and tables show trainees' city and postcode characteristics. As mentioned above postcodes are proxies of the learners' organizations/institutions (mainly schools). This analysis is useful from a commercial point of view as it could inform Ascentis' decision making on commercial activities and resource allocation.
In this regard, firstly, I will show the relationship between trainees/interventions and cities and the top 20 cities by number of interventions. Later, I will show the relationship between trainees/interventions and postcodes. Even in this case, I will show a chart with the top 20 postcodes by number of interventions.

Trainees/Interventions by city

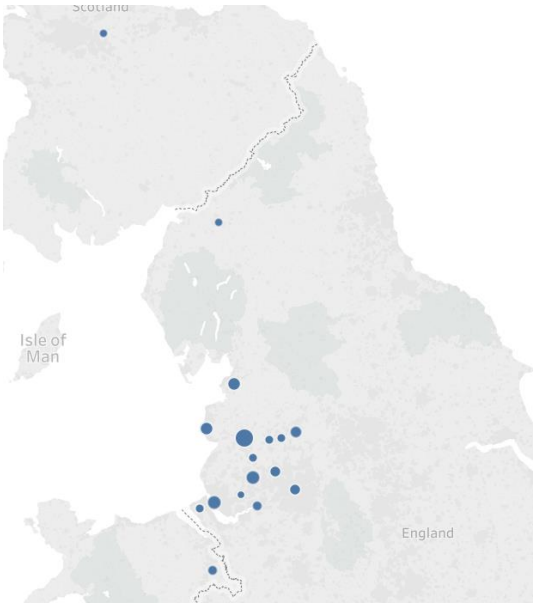


The above chart shows a high concentration of IDL interventions (63%) in relatively few cities (45 cities, 10%). The latter are cities with more than 400 interventions. Moreover, a relatively small number of IDL interventions are scattered around many cities (251 cities, 52%). In these cities the number of interventions is less than 49. The average number of interventions per city is 171.
This data can be compared with the current company's geographic resource allocation and the potential commercial development of IDL in conjunction with a specific market analysis (for example: presence of competitors and number of potential customers).

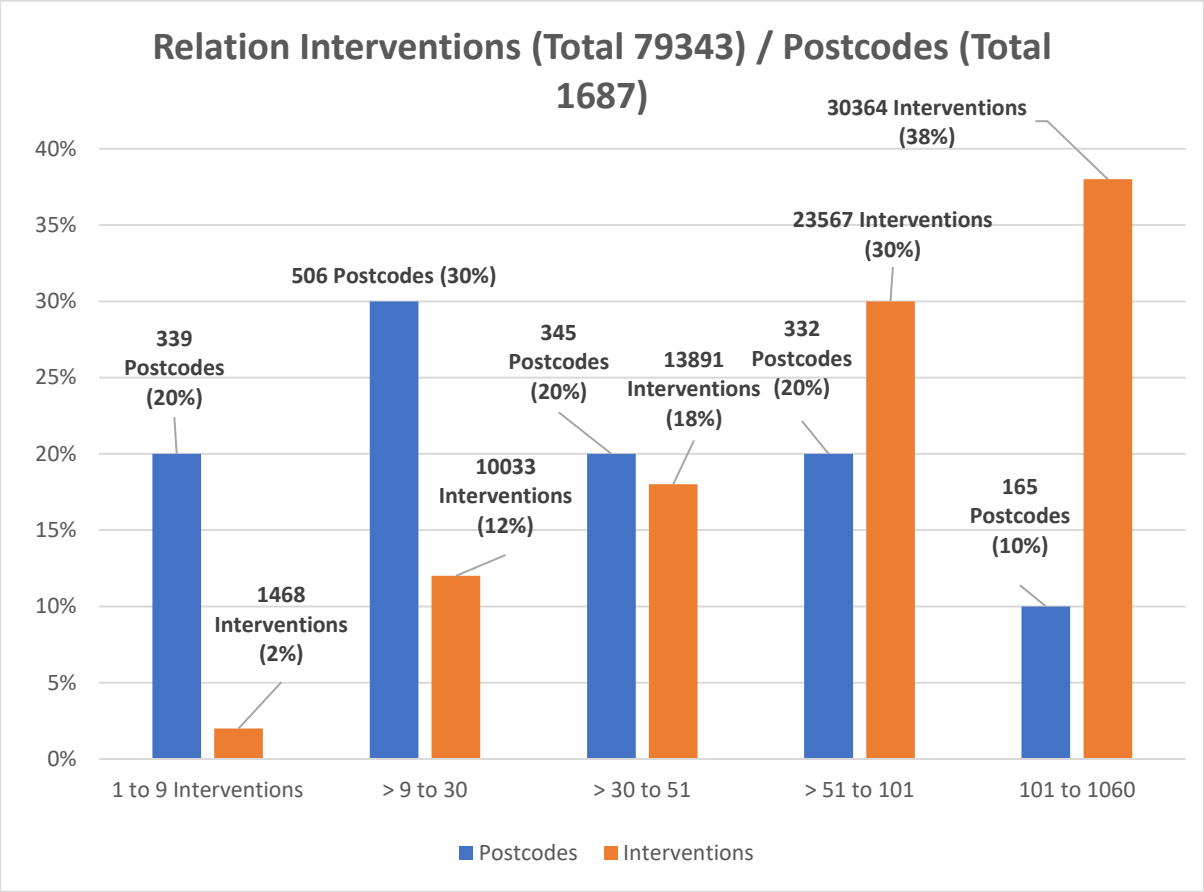
The following table and map show the top 20 cities by number of interventions. As we can see, in Preston alone there are 7% of the total number of interventions. Furthermore, top cities by interventions are concentrated in and around Lancashire county. Lancashire is certainly not the most populated part of the UK. Therefore, there are probably ample margins of commercial growth for IDL.

Top 20 Cities by number of interventions

	Cities	Interventions	%
1	Preston	5480	7
2	Wigan	2979	4
3	Liverpool	2863	4
4	Lancaster	2470	3
5	Blackpool	2354	3
6	Burnley	2107	3
7	Bolton	1892	2
8	Manchester	1770	2
9	Warrington	1489	2
10	Wrexham	1468	2
11	Chorley	1299	2
12	Blackburn	1276	2
13	Accrington	1214	2
14	Lancashire	1168	1
15	Wirral	1141	1
16	Airdrie	1057	1
17	Carlisle	1027	1
18	Cumbria	1008	1
19	Cheshire	861	1
20	St Helens	826	1

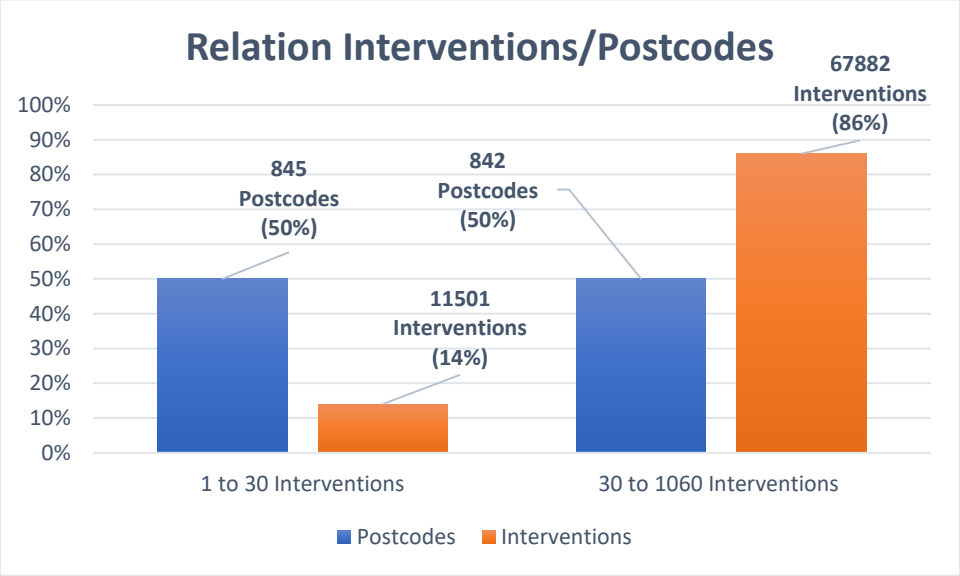


Trainees/Interventions by postcodes (Organizations/Institutions)



As mentioned above postcodes are proxies of the learners' organizations (most of them schools). The average number of interventions per postcode is 47. The above chart shows less concentration of interventions than the previous city-based analysis. However, there is a notable 38% of the interventions in 10% of the postcodes. The latter represents organizations with more than 101 learners.

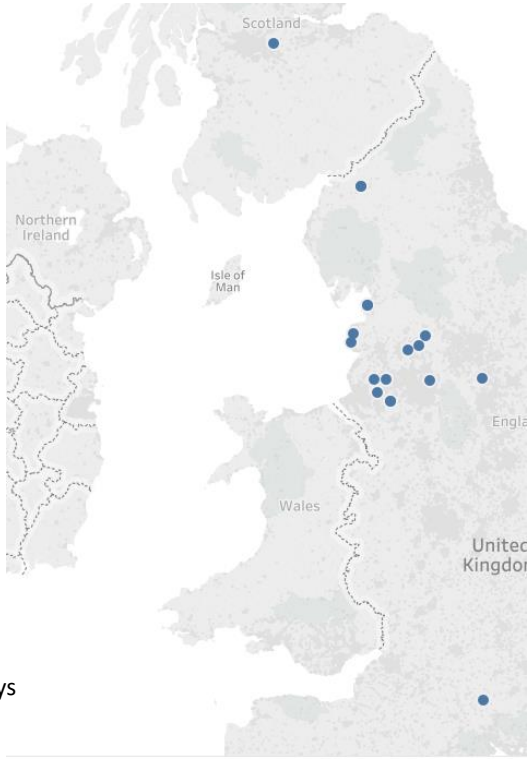
Moreover, if we concentrate this data, as it is shown in the following chart, we can see that there are 86% of the interventions in 50% of the postcodes (842 organizations with more than 30 learners). The remaining small percentage of the interventions (14%) are scattered around the other 50% of the postcodes (845 organizations with less than 30 interventions).



The following table shows the list of the top 20 postcodes by number of interventions. The map at the right side confirms the concentrations of the interventions in and around Lancashire county with few exceptions.

Top 20 Postcodes by number of interventions

	Postcode	Interventions	City
1	WN11HQ	1060	Wigan
2	WA33EL	884	Warrington
3	KW151QN	566	Kirkwall
4	RASALKHAIMAH	470	Abroad
5	LA45TH	419	Morecambe
6	CA11NA	379	Carlisle
7	FY20TS	378	Blackpool
8	SP101JZ	375	Andover
9	BB101JD	364	Burnley
10	OL99QY	347	Oldham
11	WA94HA	338	St. Helens
12	BB54AY	336	Accrington
13	WA32ED	330	Warrington
14	ML68XW	323	Airdrie
15	WN86JN	299	Skelmersdale
16	CA13QA	298	Carlisle
17	S704EB	296	Barnsley
18	FY55JR	293	Thornton Cleveleys
19	BB88JT	278	Colne
20	LA44XF	273	Morecambe



3. IDL Performance Analysis

3.1 Introduction

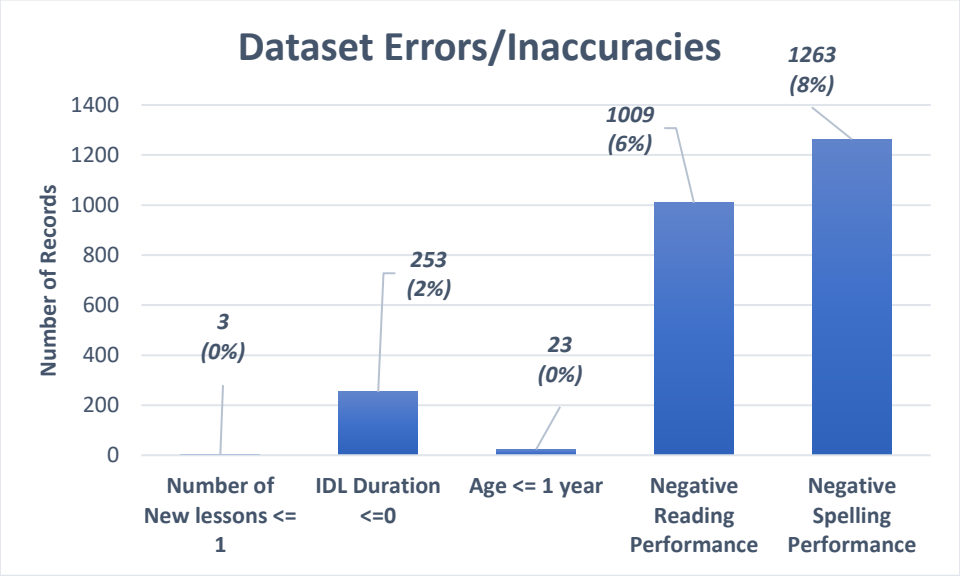
In the second part of this report, I will analyse the performance of IDL intervention considering several aspects. As mentioned above, this analysis will be based on a subset of the original group of records. Indeed, only in this subset we have performance-related data. The total number of records is 16773 and it is considerably higher than that of the previous research (150 records for Scrase, 2002 and around 700 records for Lifting Barrier Project, 2014). This is an advantage for our analysis because a large sample of data allows to estimate unknown parameters of a population more precisely than a small sample of data.[8]

3.1.1 Operative context and errors in the dataset

Our research is based on data collected on an 'operative' rather than 'test' environment (such as that of previous studies: Scrase, 2002 and Lifting Barrier Project, 2014). This brings the advantage of analysing a large sample of data. However, our dataset will contain some errors and inaccuracies for inevitable human errors and the less controlled environment this research is based on.
The number of these errors is relatively small, will be considered in the data analysis and will represent a starting point to suggest improvements to IDL.
In this regard, evident errors in our dataset are birthdates that follow IDL intervention start dates, IDL intervention start dates that follow end dates, or new lessons equal zero in presence of after-intervention performance tests. Furthermore, less evident instances of these errors are records that show negative after-intervention performances (a regression in reading and spelling competence). These last records contain errors for three main reasons. Firstly, the presence of other kinds of errors in the dataset allows to assume that there could also be this type of errors. Secondly, dyslexia is not a degenerative disease per se. "People with dyslexia are born with it and it does not get any worse as they age". (Winchester, ND). Finally, consistency in the test environment is a fundamental prerequisite for reliable results. In the 'operative' context described above it can be considered normal that a number, although small, of tests were not properly completed.

The following chart shows the type and amount of the errors in our dataset. Later, a table summarizes these data and suggests related improvements to IDL.

[8] This can be exampled by the 'law of large numbers' (Routledge, ND)



Error/Inaccuracy	Records	%	Suggested improvement
Number of New lessons <= 1	3	0	Controls on Test (post-intervention) field/availability
IDL Duration <=0	253	2	Controls on Intervention End Date field
Age <= 1 year	23	0	Controls on Birthdate field
Negative Reading Performance	1009	6	Improve training on running performance tests and related software interface
Negative Spelling Performance	1263	8	Improve training on running performance tests and related software interface

3.2 Reading and spelling related performance gain analysis

I will separately analyse reading and spelling related performance considering IDL duration, and the number and frequency of new lessons. Later I will compare the performance of some groups of trainees (males vs females, age groups) and the relationship between age and post intervention performance. The following table summarizes the list of analyses of this part of the report.

Analyses

	Reading	Spelling
Duration	✓	✓
Number of new lessons	✓	✓
Frequency of new lessons	✓	✓
Male Vs Females	✓	✓
Key 2 vs Key 3 Stages	✓	✓
Age	✓	✓

3.2.1 Reading and spelling related performance gains and IDL duration

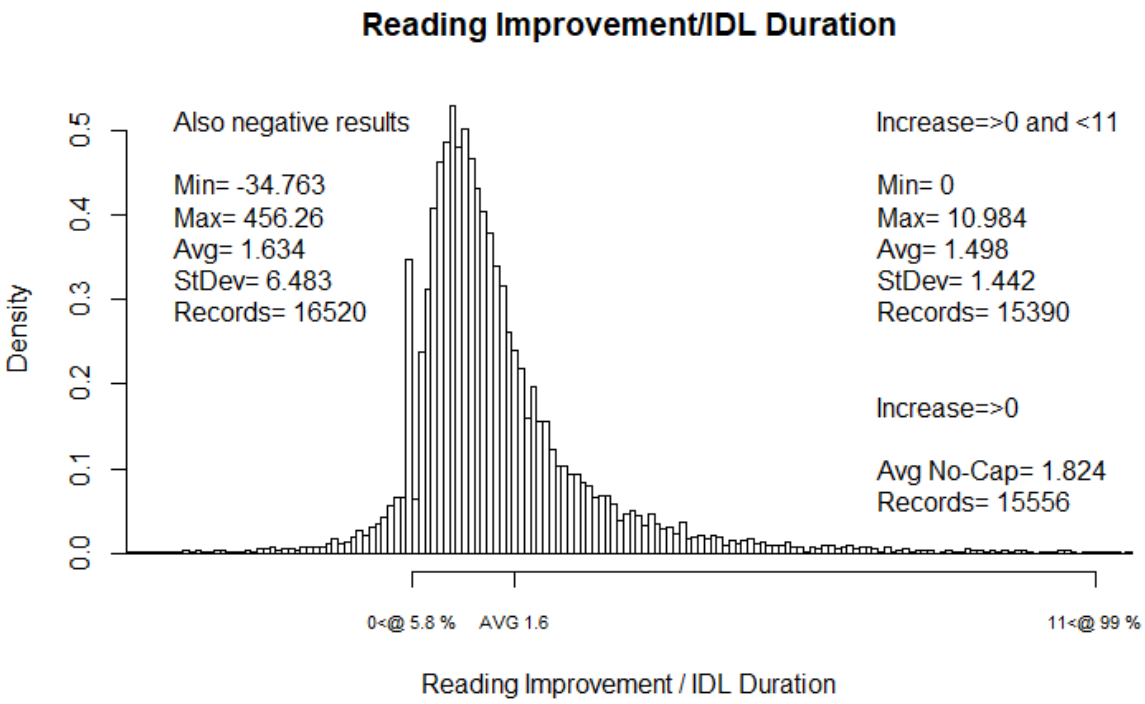
3.2.1.1 Introduction

In this paragraph I will analyse the relationship between the duration of IDL intervention and the increase in reading and spelling related performance. The measure of the latter is based on the Schonell Test (Schonell and Schonell, 1950) and is represented by the corresponding age (in days) of a subject with normal linguistic development/competence. Thus, the increase in performance will be the difference in 'age' between the performance at the start of an IDL intervention and the performance at its end. This measure is compared with the overall duration of the intervention.

Example
Reading-related performance age at intervention start: 10 years, 1 month Reading-related performance age at intervention end: 12 years, 2 months Difference: 2 years, 1 months = 760 Days Intervention duration = 380 Days Ratio Performance Increase/Duration = 760/380 = 2

I will describe my analysis with the help of 2 couples of graphs (the first couple for reading and the second for spelling). The first graph of each couple is a histogram that shows a frequency distribution of the ratio performance/IDL duration. The second is a two-dimensional graph that shows the linear relationship between performance and duration.

3.2.1.2 Relationship between reading-related improvements and IDL duration



The above chart is a reading-related performance/duration ratio density distribution. The curve has a positive skewness value and its average is 1.634 ('Avg' on the left-top side of the chart). This means that on average 1 day of IDL intervention will improve the reading performance of 1.634 days. This measure can be partially[9] compared with related values in Scrase (2002) and confirms the superiority of IDL against other kinds of dyslexia intervention (0.58)[10].

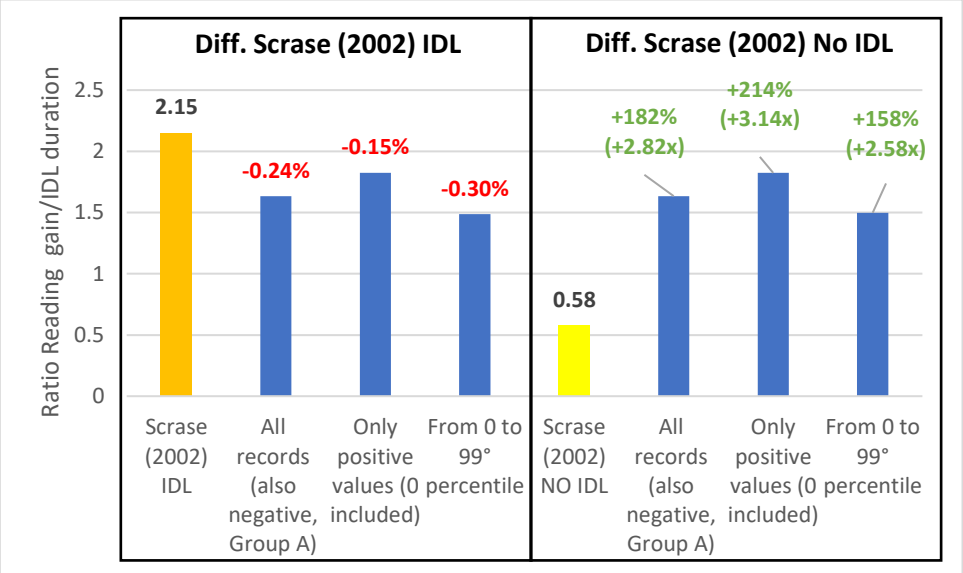
The chart also shows other two averages 'Avg' (on the right side of the chart).

While the average value of 1.634 ('Avg' on the left side) is calculated including also negative values (decrease in reading performance), the other two averages are calculated, one excluding all negative values (1.824 on the bottom-right side of the chart), and the second with values from 0 (zero included) to the value of the 99° percentile (thus excluding also extreme positive values. **1.498 on the top-right side of the chart.).** As expected, the average that only excludes negative values shows the highest performance.

The calculation of three different averages allows to evaluate the effect of possible errors in our statistic due to the 'operative' nature of the analysis.

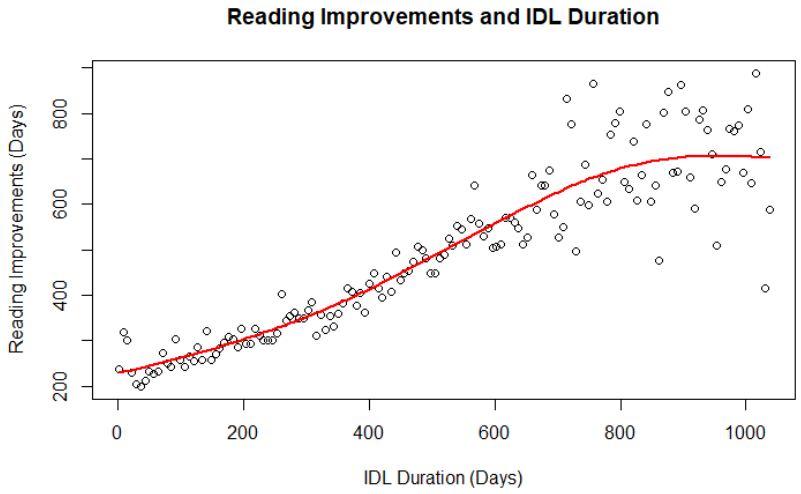
The following table and chart summarise our results and compare our averages with those of the previous research (Scrase, 2002).

[9] We do not have precise information about the lesson frequency.
[10] This value refers to the group of learners of Scrase (2002)



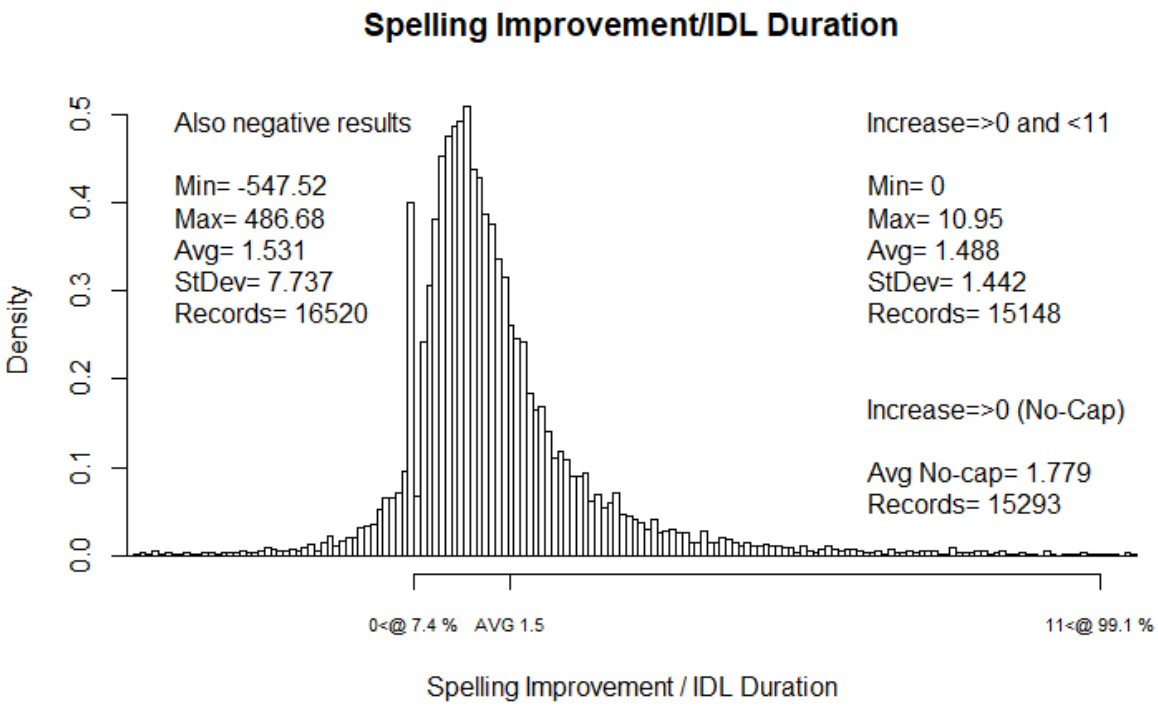
Averages	Value Reading	Diff. Scrase (2002) IDL (2.15)	Diff. Scrase (2002) No IDL (0.58)
All records (also negative, Group A)	1.634	-0.516 (-0.24%)	+1.054 (+182%) (2.82x)
Only positive values (0 included)	1.824	-0.326 (-0.15%)	+1.244 (+214%) (3.14x)
From 0 to 99° percentile	1.498	-0.652 (-0.30%)	+0.918 (+158%) (2.58x)

The following two-dimensional graph shows a linear positive relationship between reading performance and IDL duration.

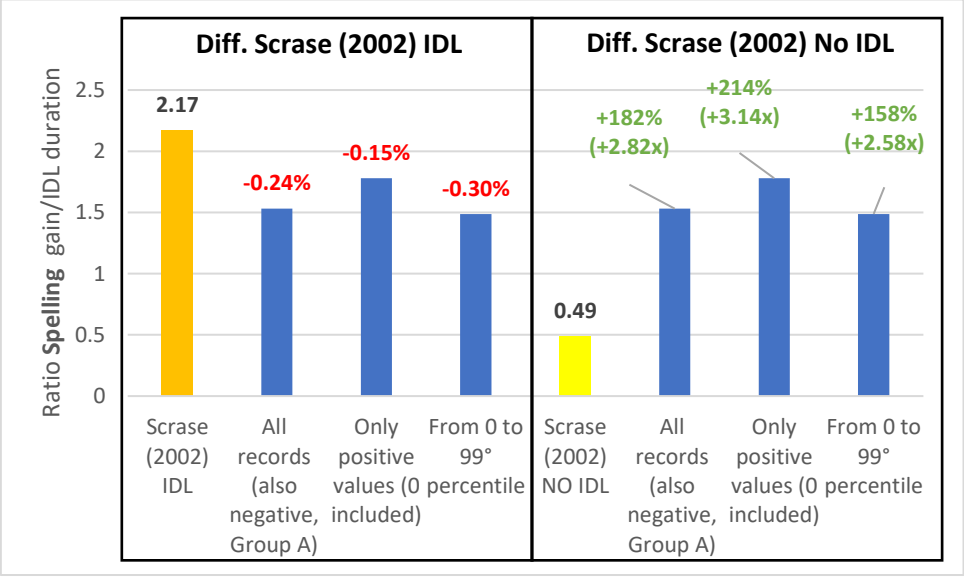


While it is clear (and it is easily foreseeable) a positive relationship between reading performance and IDL duration, **the graph also shows a flat line (no improvements) and more scattered results for values of IDL duration higher than 800 days (2 years and a half).**

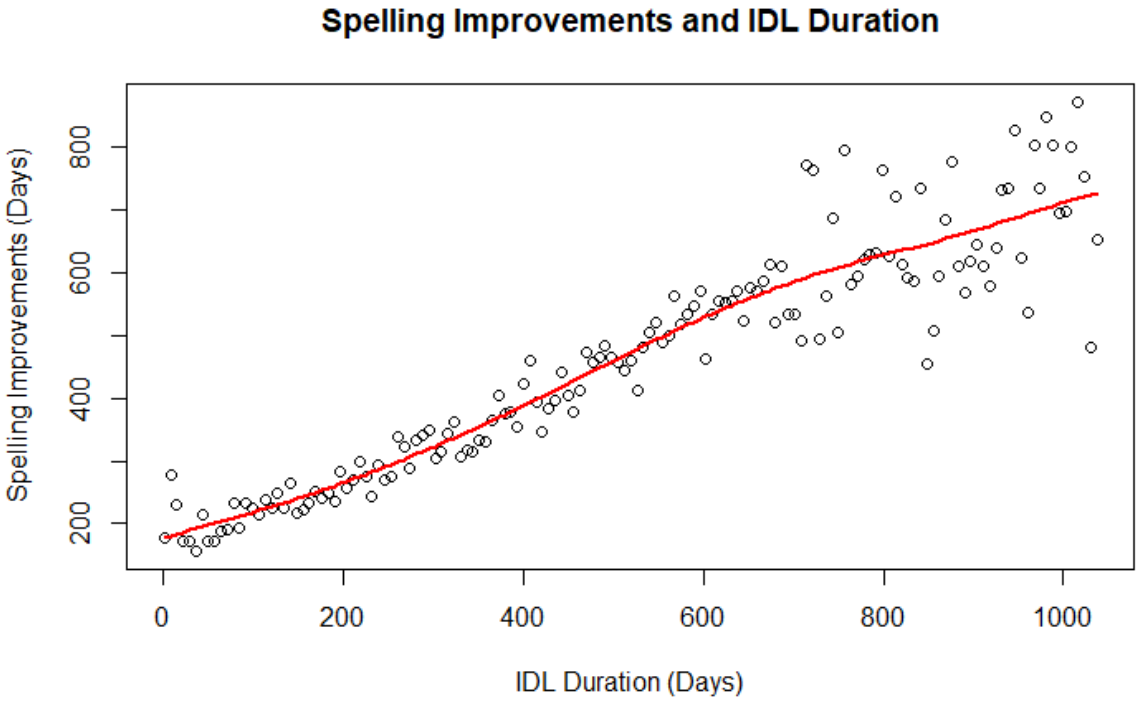
3.2.1.3 Relationship between spelling-related improvements and IDL duration



The above chart is built in a similar way as the previous reading-related chart. In this case, the density distribution regards the ratio between spelling improvement and IDL duration. The three averages are calculated based on the same criteria previously described. Follows a chart and a table that summarize the results:



Averages	Value Spelling	Diff. Scrase (2002) IDL (2.15)	Diff. Scrase (2002) No IDL (0.58)
All records (also negative, Group A)	1.531	-0.639 (-0.29%)	+1.041 (+212%) (3.12x)
Only positive values (0 included)	1.779	-0.391 (-0.18%)	+1.289 (+263%) (3.63x)
From 0 to 99° percentile	1.488	-0.682 (-0.31%)	+0.998 (+204%) (3.04x)



The above graph shows a positive linear relationship between spelling-related performance and IDL duration. Moreover, **for IDL duration values longer than 800 days, although results tend to be more scattered, the curve maintains a positive inclination (as opposed to the previous reading-related graph).**

3.2.1.4 Conclusions after this part of the analysis

This part of the performance analysis has produced results that can be compared with those of the previous research. In this regard, although our reading and spelling values are lower than those measured by Scrase (2002), they are significantly better than those obtained with other forms of intervention. Furthermore, our results are obtained on an operative environment rather than on another test environment. This means that the effectiveness of IDL intervention does not require a strict control of its operations.

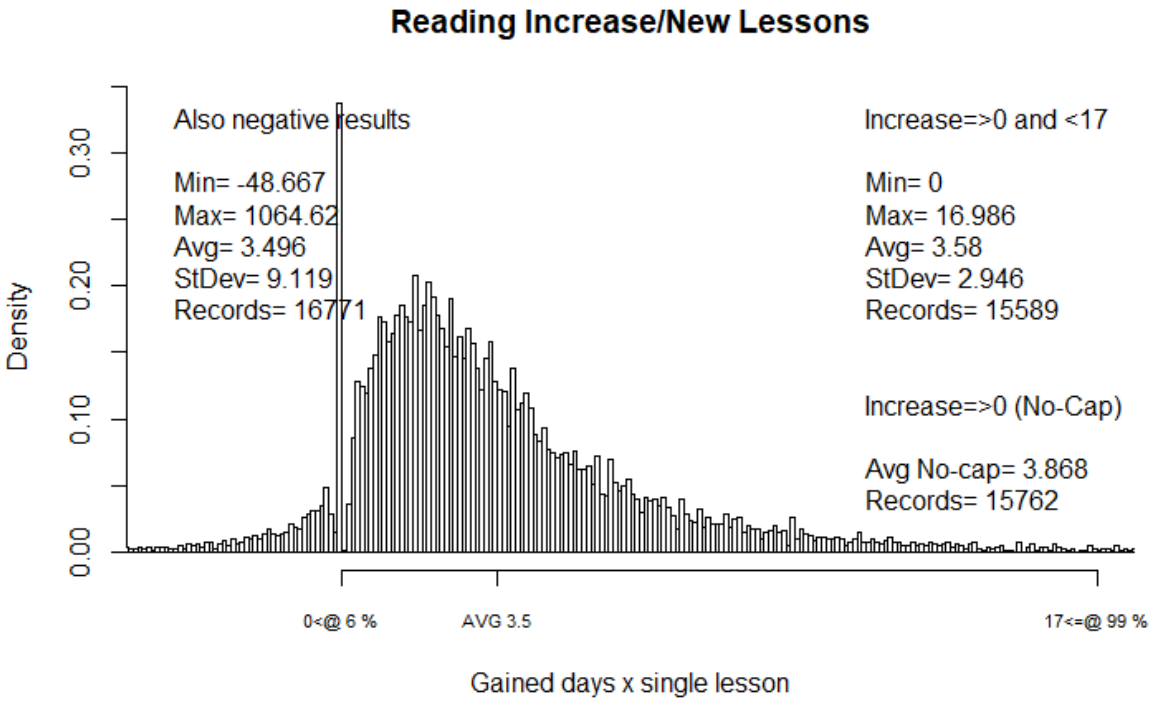
Altogether, this analysis confirms the results of the previous research and shows the flexibility, robustness of IDL intervention.

3.2.2 Reading and spelling performance gain and number of new lessons

3.2.2.1 Introduction

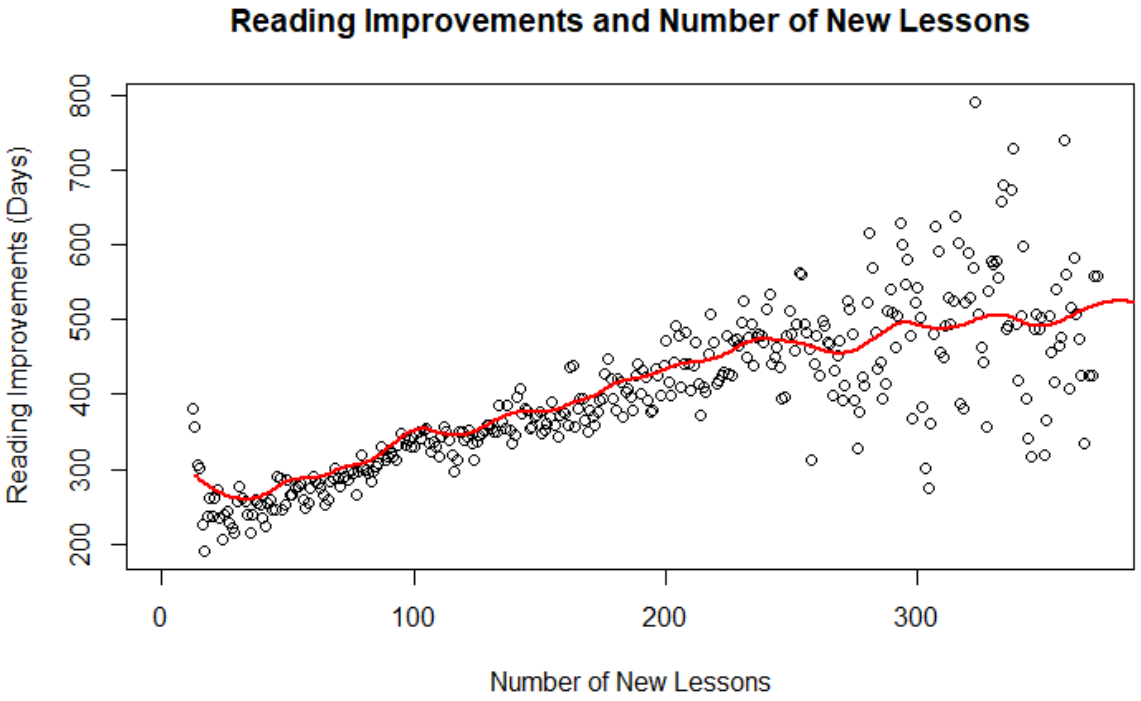
In this paragraph I will separately analyse reading and spelling performance in relation to the number of new lessons. In this regard, similarly to the previous paragraph, I will show 2 couples of graphs (the first couple for reading, the second for spelling). The construction of the graphs is similar to that of the previous analysis[11]. Even in this case, each couple is formed by one histogram and one two-dimensional linear graph. Moreover, the two histograms will show three averages calculated with the same criteria as described above. This time the averages show a measure of the performance gain (in terms of days) per each new lesson.

3.2.2.2 Relationship between reading-related improvements and new lessons



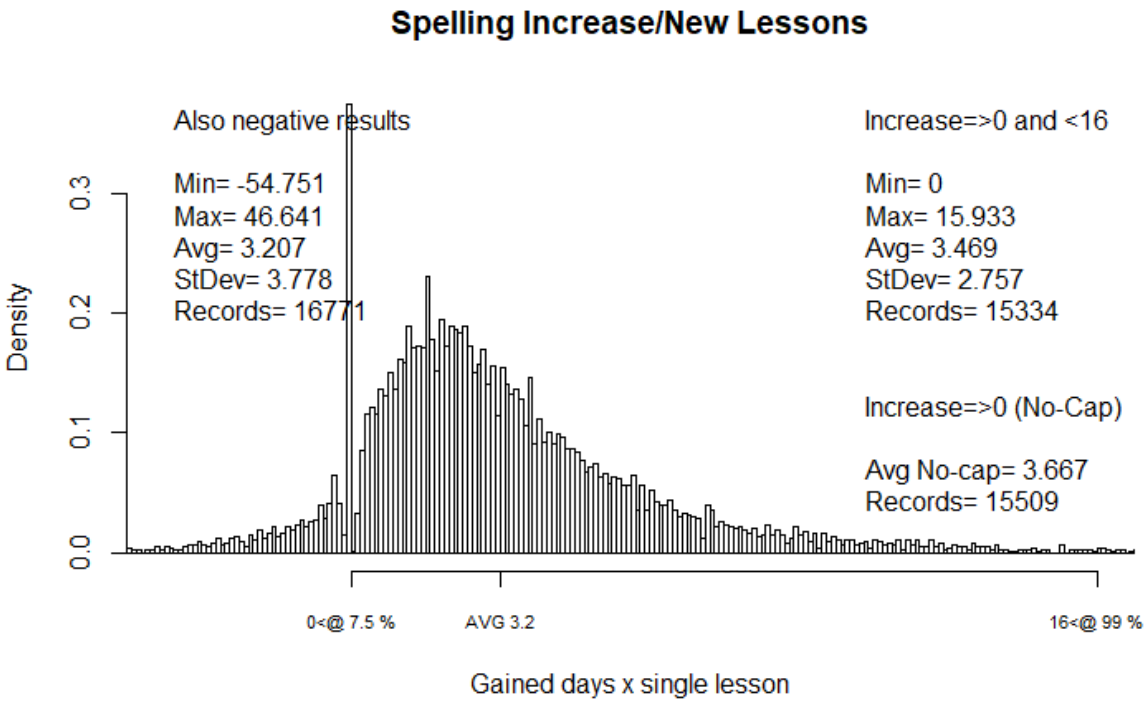
The above chart shows that one new IDL lesson increases, on average, the reading-related performance of around 3.5 days.

[11] Performance is based on the Schonell Test (Schonell and Schonell, 1950) and measured as the corresponding age (in days) of a subject with normal linguistic development/competence.

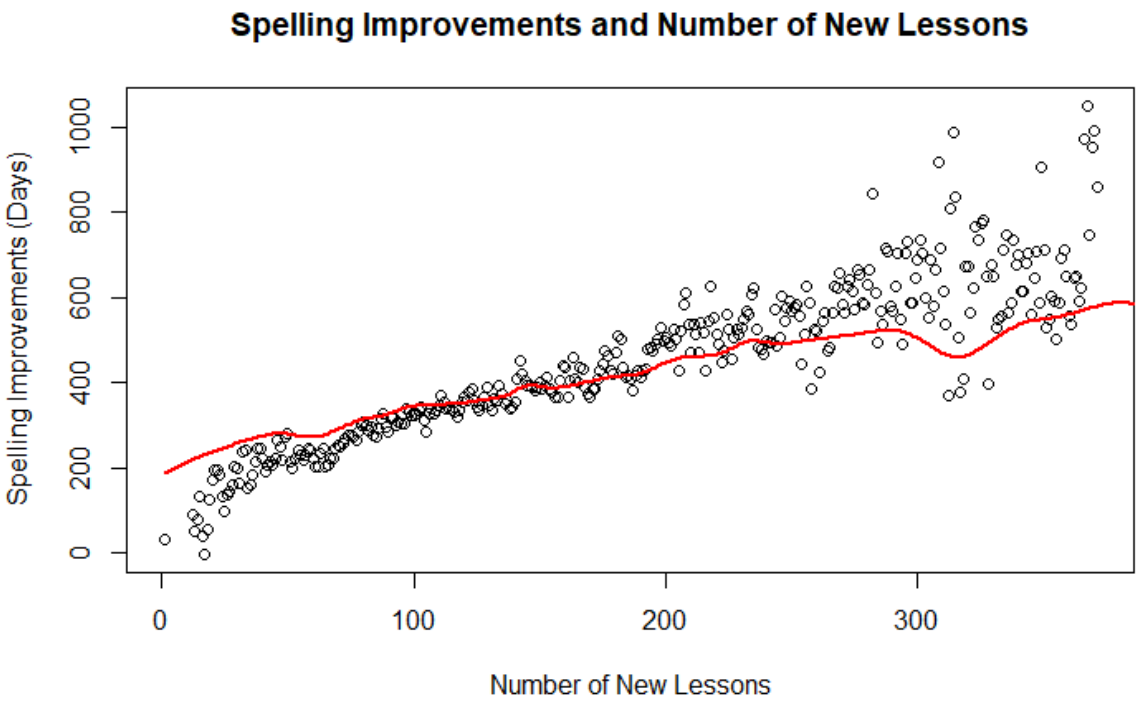


The above graph shows a positive linear relationship between reading performance gain and number of new lessons. From around 220 / 230 new lessons onward, results are more scattered.

3.2.2.3 Relationship between spelling-related improvements and new lessons



The above chart shows that **one new IDL lesson produces, on average, a spelling-related performance gain of around 3.4 days.**



The above graph confirms a positive linear relationship between performance gain (in this case spelling-related) and number of new lessons. From around 260 / 270 new lessons onward, results are more scattered.

3.2.2.4 Conclusions after this part of the analysis

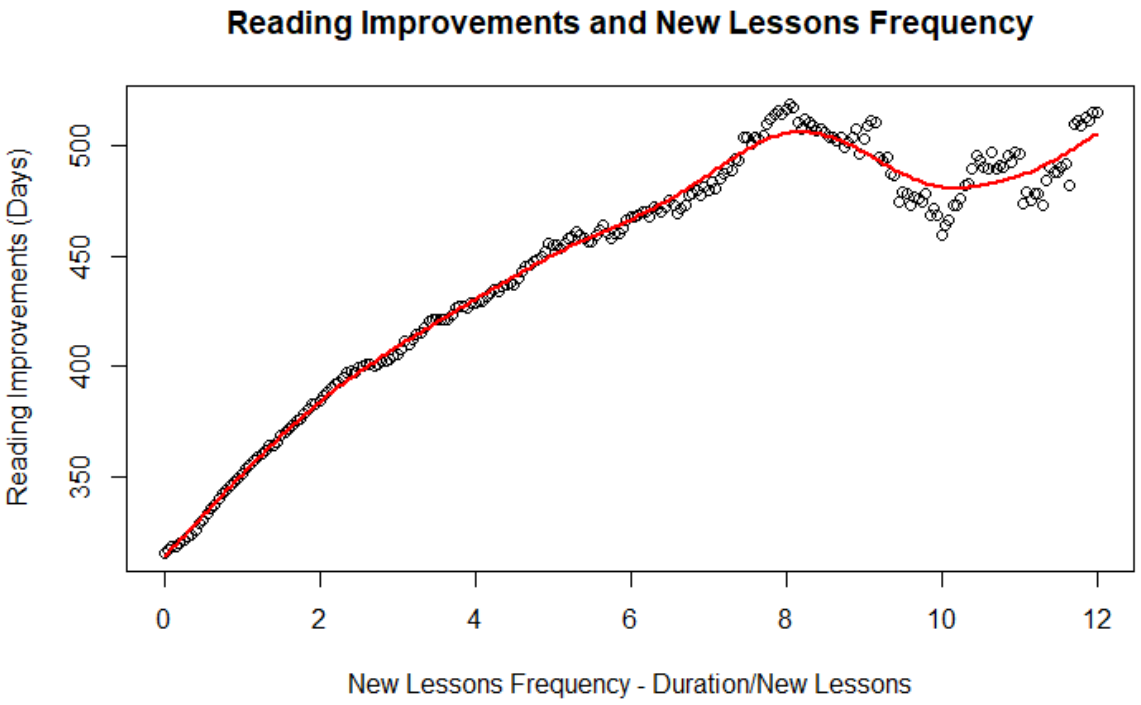
Our analysis allows to conclude that 1 new IDL lesson produce a reading-related performance gain **of around 3.5 days** and a spelling-related performance gain **of around 3.4 days.**

3.2.3 Reading and Spelling performance gain and New lessons frequency

3.2.3.1 Introduction

In this paragraph I will analyse the variation in performance gain (reading and spelling) based on an estimation of the new lessons frequency. The latter is measured as the ratio between IDL duration and number of new lessons.
Although the data is not precise because of **the lack of the time of each lesson**, the analysis will provide precious insights for the optimization of IDL performance.
In this regard, I will show and analyse two graphs. The first is related to reading, the second to spelling.

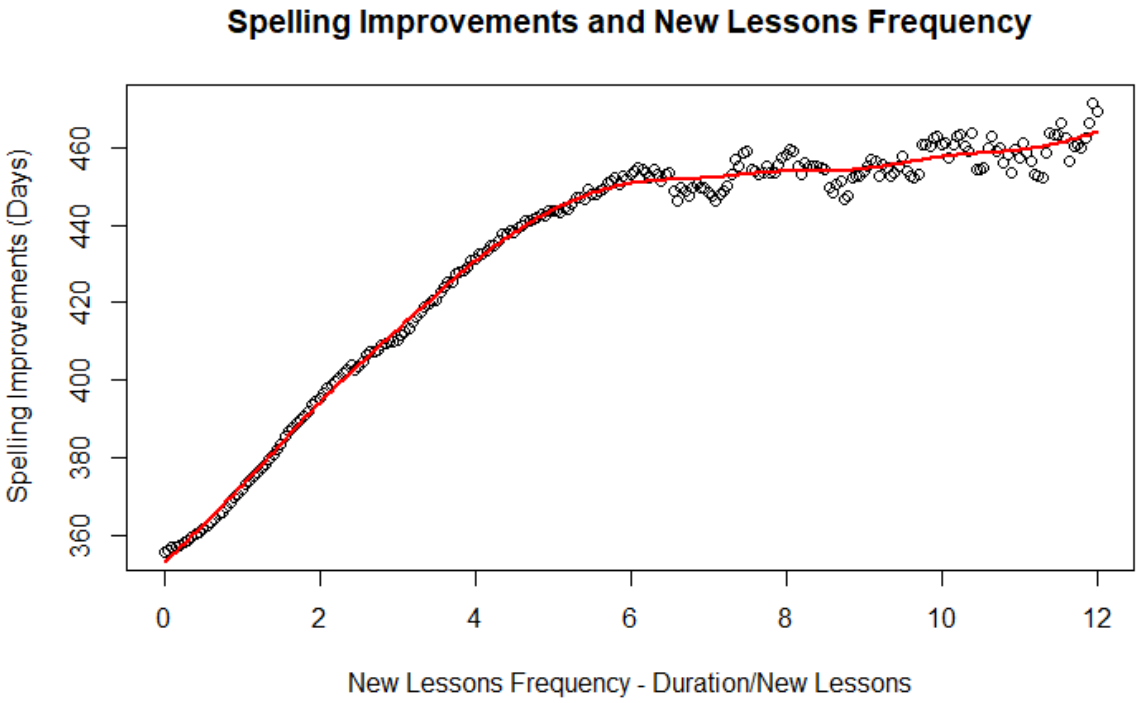
3.2.3.2 Relationship between reading-related improvements and new lessons frequency



The above graph shows the variation in reading-related performance gain (from 0 to more than 500 days) based on the frequency of new lessons (from 0 to 12, limited to the 99' percentile). The latter is measured as the ratio between IDL duration and number of new lessons. Thus, as an example, a value of 4 indicates a frequency of 1 new lesson every 4 days.

The curve shows that the **optimal frequency value is 1 lesson every 8 days.** For frequency values higher that this there is not any increase in reading-related performance.
As mentioned above, the analysis is based on a **rough estimation** of the frequency of new lessons. Thus, the only definitive and precious insight of this analysis is **that IDL lessons should be carried out without any rush and with repetitions** to optimize the performance gain.

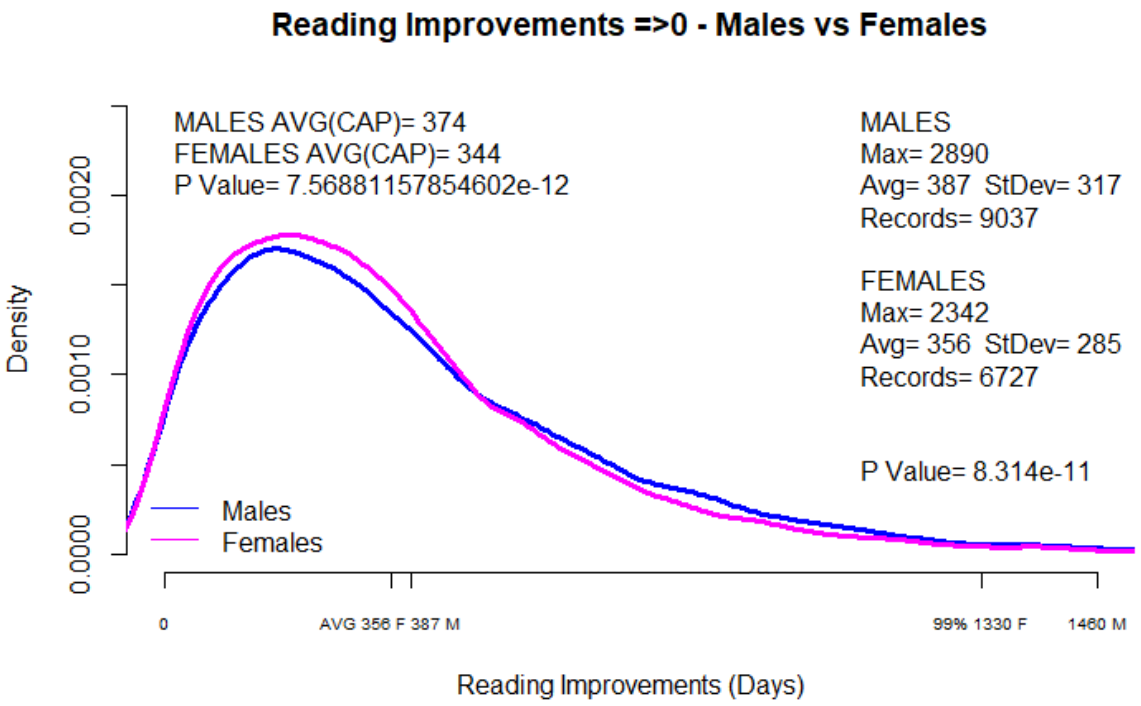
3.2.3.3 Relationship between spelling-related improvements and new lessons frequency



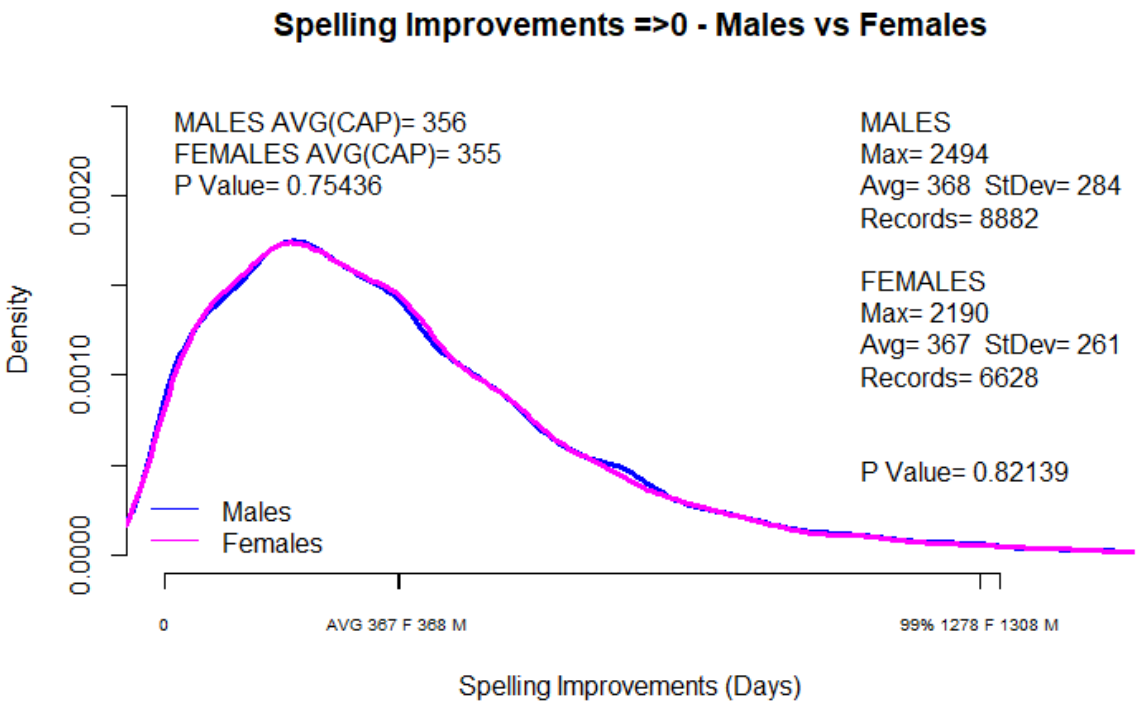
The graph of the variation of spelling-related performance gain that depends on the frequency of new lessons has the same characteristics as the previous graph. In this case, the curve shows **an optimal frequency of 1 new lesson every 6 days. Even this analysis provides only a rough estimation of the optimal frequency value and confirms the need to distribute the lessons over a period of time that allows trainees to repeat, elaborate and stabilize the effects provided by their new training.**

3.2.4 Gender-based differences in reading and spelling related performance gains

In this paragraph I will analyse the difference in reading and spelling performance gains (if any) between the two groups of male and female IDL trainees.
In this regard, I will first show a reading-related graph. Later, I will show a spelling related graph.



The above graph is slightly different than those we have seen so far. In it we can see two density curves. One curve shows the distribution of performance gains related to the male group of trainees (blue curve). The second curve is related to the female group (pink/purple curve).
The graph also shows two couples of averages (Avg).
The first couple, on the right side of the picture, shows reading performance gain averages for each of the two groups (387 days for males and 356 for females). These averages are based on all positive performance values.
The second couple of averages, on the top left side of the picture, (374 days for males and 344 days for females) are based on all positive performance values within the 99' percentile.
From our analysis we can conclude that **males tend to have higher reading-related performance gains than females.** The difference in the averages of the two groups is statistically valid (P Value < 0.01).



The spelling-related graph of the difference in performance gains between males and females has the same characteristics as those of the reading related graph. **In this case, males and females show almost identical spelling-related performance gains following IDL interventions (356 days for males and 355 for females)[12].**

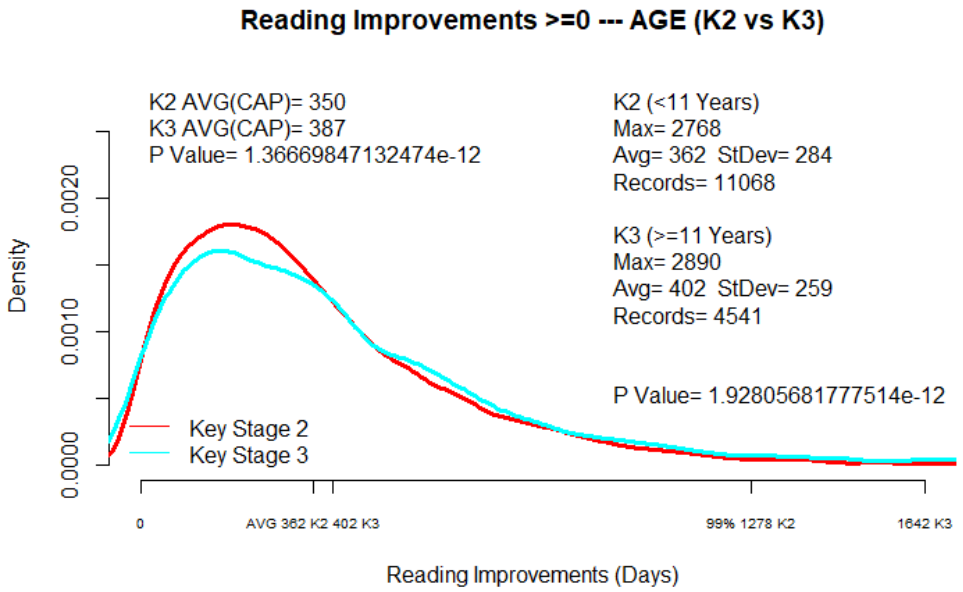
3.2.5 Age-based differences in reading and spelling related performance gains

3.2.5.1 Introduction

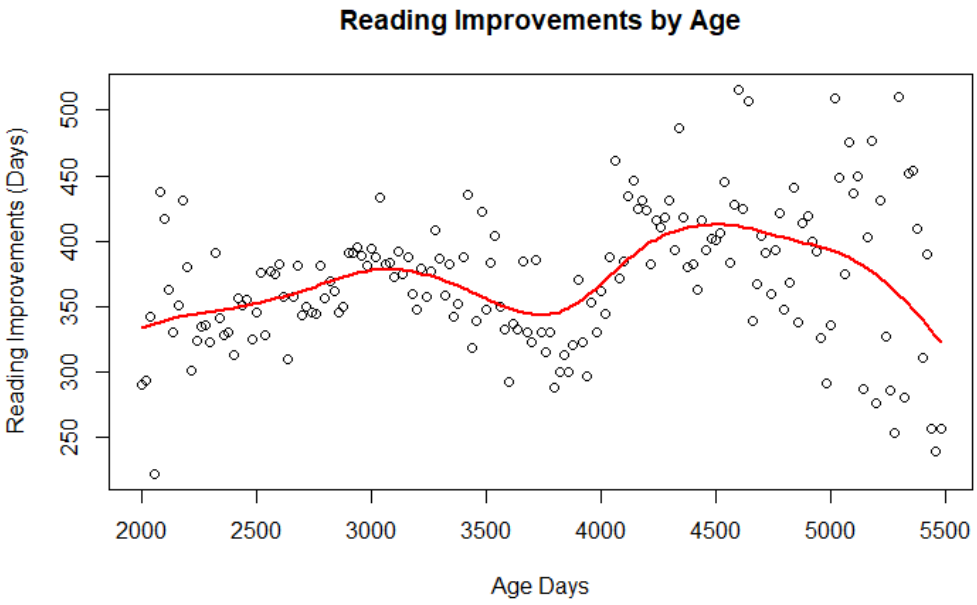
In this paragraph I will describe age-based differences in reading and spelling related performance gains. In doing so I will show two couples of graphs. The first couple will be related to reading performance gains. The second couple shows spelling-related performance gains.
The first graph of each couple compares two density curves. These show the distribution in performance gain of two groups of trainees. The first curve (red) is related to Key stage 2 trainees (younger than 11 years) (BBC, 2015). The second (light blue curve) shows the performance gain distribution of Key stage 3 trainees (older than 11 years) (BBC, 2015).
The second graph of each of the two couples shows by means of a single curve the variation in performance gain depending on the trainees' age. It represents a more detailed analysis of the performance gain variation than the first graph. Indeed, it shows the variation in performance gain also inside each age group.

[12] Averages based on positive values within the 99' percentile

3.2.5.2 Age-based differences in reading-related performance gains

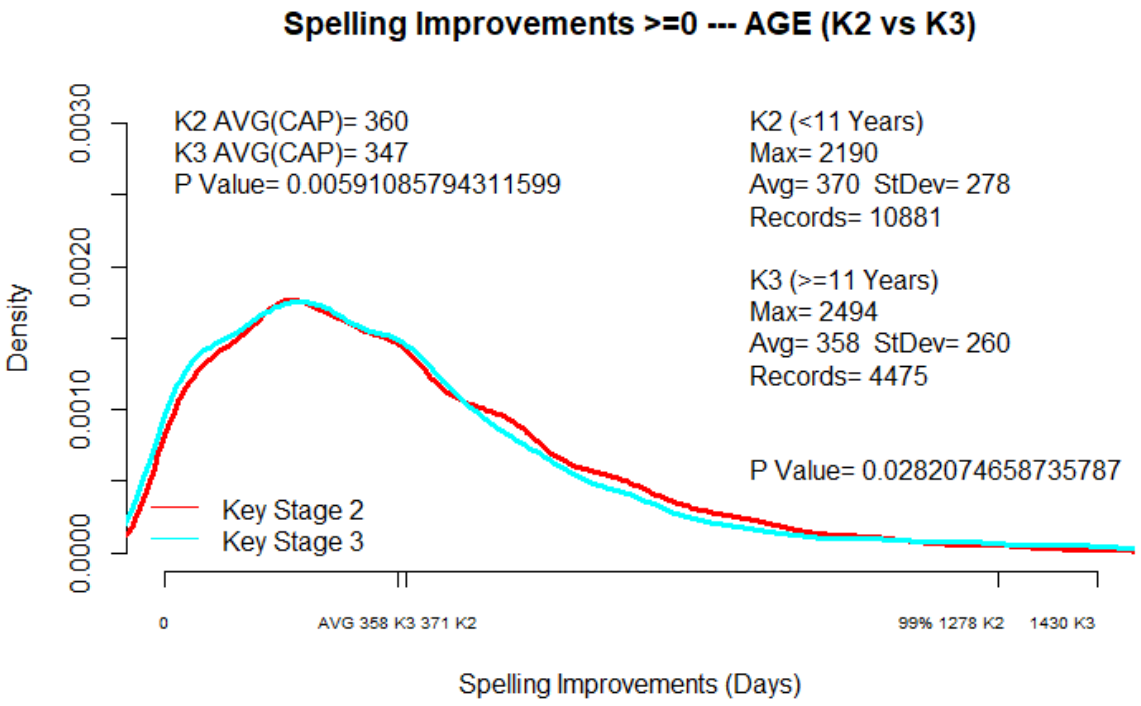


The first reading-related graph has the same characteristics as the previous gender-based graphs. Even in this case, we have two curves that show the distributions in performance gain of two groups of trainees. We have also two couples of averages. The first couple (right side of the graph) is based on all positive performance gain values. The second couple (top-left side of the graph) is based on positive values within the 99' percentile. The analysis shows a statistically valid (P Value < 0.01) difference between the two analysed groups. Notably, **the Key Stage 3 group performs better than the Key Stage 2 group. Indeed, the first group shows a reading-related performance gain average of 387 days. The second only 350 days.**

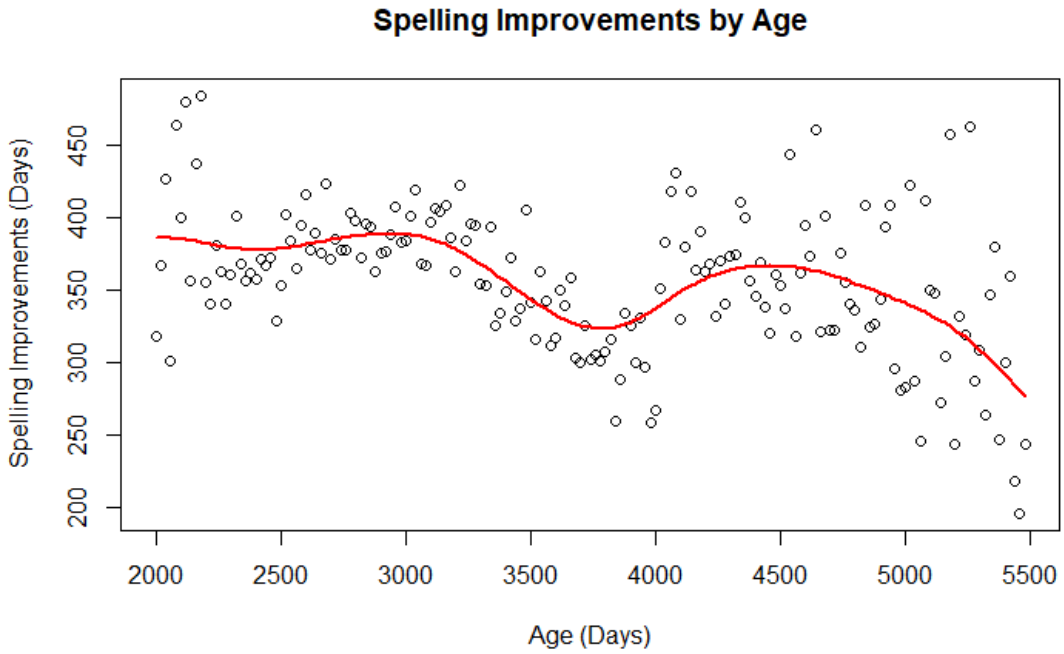


The second reading-related graph shows some details of performance gain variations based on the trainees' age. The horizontal coordinate shows the trainee's age. The vertical coordinate shows the performance gain.
From the image it is possible to identify the two age groups. Indeed, the part of the curve before 4000 days represents the Key Stage 2 group. Over 4000 days, the curve identifies the Key Stage 3 group.
This graph confirms the previous age-based analysis because the part of the curve over 4000 days is 'higher' than the other part.
Moreover, **we can note that the curve has a two-humped form. This shows that, for each educational cycle (Key Stages 2 and 3), there is an initial increase in performance gain with a peak at approximatively its middle. Later, at the end of the cycle, there is a decrease.**
The reasons of this two-humped trend could be analysed including other data (for example, information about motivation or school programmes on IDL trainees).

3.2.5.3 Age-based differences in spelling-related performance gains



The first spelling-related graph shows a statistically valid (P Value < 0.01) difference between the Key Stage 2 and Key Stage 3 groups**. In this case, however, the Key Stage 2 group performs better than the Key Stage 3 group. On average, the Key Stage 2 group shows a spelling-related performance gain of 360 days. The Key Stage 3 group a performance gain average of only 347 days.**



The second spelling-related graph confirms the first analysis because the part of the curve over 4000 days is 'lower' than the other part. Moreover, **even in this case, the curve has a two-humped form replicating the trend that we have previously seen for the reading-related analysis.**

The fact that older trainees achieve lower results in spelling improvements, on the one hand, could shed light on theories related to the relationship between age and language acquisition (for example the Lenneberg's critical period hypothesis (CPH), (Snow and Hoefnagel-Hohne, 1978)). On the other hand, it could improve the understating of the mechanisms that determine the efficacy of IDL intervention and could allow these same mechanisms to be improved.
However, a further examination of the result of this analysis and of those of the previous paragraphs, and consequently the occasion to shed light, generally, on important language development mechanisms and, in particular, on other important details of IDL intervention is possible only with data that is currently missing. I will further discuss this aspect in the following and conclusive paragraph of this report.

4. Conclusions

In this conclusive paragraph, I will first summarize the results of the analysis. Later, I will suggest improvements to IDL data collection and management.
My suggestions will have two aims. On the one hand, they are addressed to support the development of IDL. In this regard, I have identified margins of improvement. On the other hand, my suggestions could hopefully support and further expand the commercial development and management of IDL.

4.1 Summary of the analysis.

IDL interventions analysed on an 'operative' environment rather than on a 'test' environment have confirmed their efficacy in helping to 'lift the barrier' between dyslexic subjects and their ability to

read and spell properly. Notably, we have quantified this efficacy and we have been able to compare one of our result (the relationship between reading and spelling performance and IDL Duration) with that of the previous research.
In this regard, one day of IDL Intervention determines improvements of around 1.5 days (measure based on the Schonell test standard (Schonell and Schonell, 1950)) in reading and spelling ability. Improvements are slightly higher for reading than for spelling.
As regards the relationship between IDL efficacy and number of new lessons, each IDL lesson determines reading improvements for 3.58 days and spelling improvements for 3.468 days. Even in this case, we have slightly better results for reading than for spelling.
Reading and spelling related improvements compared with a measure of the frequency of new lessons show the need to distribute new lessons over a period of time that allows trainees to repeat, elaborate and stabilize the effects provided by the new training. The ideal period of time between each new lesson is longer for reading than for spelling.
A comparison between genders shows, on the one hand, that males perform better than females in reading (IDL Intervention total improvements: Males = 374 days vs Females = 344 days). On the other hand, there is not any spelling-related performance difference between these two groups (Males = 356 days vs Females = 355 days).
Finally, while the Key stage 3 group performs better than the Key stage 2 group in reading (Key stage 2 = 350 days vs Key stage 3 = 387 days), as regards spelling, the Key stage 2 group performs better than the other group (Key Stage 2 = 360 days vs Key stage 3 = 347). This analysis also shows that there is a decrease in performance improvements at the end of each Key stage period (two-humped curve).

Summary Table

	Reading	**Spelling**
Improvements / IDL duration	1.498[13] days for each IDL day	1.488[14] days for each IDL day
Improvements / IDL New lesson	3.58 days for each IDL new lesson	3.468 days for each IDL new lesson
Improvements / IDL new lessons frequency	Optimal value: One new lesson every 8 days (this quantification is not precise for the lack of data)	Optimal Value: One new lesson every 6 days (this quantification is not precise for the lack of data)
Improvements / Gender	Males = 374 days / Females = 344 days	Males = 356 days / Females = 355 days (No significative difference)
Improvements / Age	Key stage 2 = 350 days / Key stage 3 = 387 days – (two-humped curve, improvement peak in the middle of each key stage period)	Key Stage 2 = 360 days / Key stage 3 = 347 - (two-humped curve, improvement peak in the middle of each key stage period)

[13] Schonell test standard
[14] Schonell test standard

4.2 Suggestions for future improvements[15]

Even though IDL has shown to be a valid dyslexia-related piece of software, there is opportunity and space for improvements. Indeed, on the one hand, it is possible to better understand and consequently optimize, the functioning of IDL interventions through the collection of more data. On the other hand, having collected these new data it is possible to use modern digital technologies such as AI and 'on the fly' visual analytical tools to efficiently deliver this optimization. Moreover, new digital technologies would also be useful to manage and expand the commercial presence of IDL.

1) Collecting new data[16]

The collection of new data is the first and necessary step to improve IDL. With regard to this, I am not only suggesting collecting a greater quantity of data, but new types of data. Indeed, when conducting my analysis, I perceived the lack of at least three kinds of data in the dataset.

Dyslexia type: The first and probably most important data that was missing is the type of dyslexia diagnosis. Dyslexia experts widely recognize that people with dyslexia are not all the same. Put it in another way, we can say that there are many types of dyslexia. In this regard, there is not consensus among experts on a precise categorization of dyslexia types. On the contrary, there are various related theories. For example, Ramus at al (2003) analyse three theories: The phonological theory, the magnocellular (auditory and visual) theory and the cerebellar theory.
Although there is a lack of consensus among expert on this point, the characterization of IDL intervention with the diagnosis of the dyslexia type is very useful for two reasons. On the one hand, it could shed light on the categorization problem. On the other hand, the identification of groups of trainees based on their diagnosis could be an occasion to personalize the intervention and consequently optimize/improve the performance of IDL intervention. Indeed, linking the diagnosis-related data with those of the type of lessons, frequency of the latter, and achieved results could inform and possibly be an occasion to optimize the overall process.

Type of lessons: Probably not all IDL lessons are the same and could be subjected to categorization. For the same reasons as above described, the collection of data related to the type of lessons that are part of an IDL intervention, linked to other types of data, such dyslexia diagnosis, lesson frequency, and performance outcomes, could inform and be an occasion to optimize the overall intervention.

Lesson frequency: The analysis of the relationship between performance and new lesson frequency has established the need to distribute the lessons over a period of time that allows trainees to repeat, elaborate and stabilize the effects provided by IDL training. However, this conclusion is not precise because of the lack of necessary data. Notably, the current dataset does not include the time of each new lesson, nor the time and the number of repeated lessons. Consequently, in the current

[15] I have previously discussed about some other improvements to the 'operativity' of IDL intervention. I will not repeat them in this paragraph.
[16] This suggestion alone will probably determine the need to update the technology behind IDL.

analysis, the frequency calculation is based only on the number of new lessons and the period of time calculated as the difference between start and end of the intervention. The latter could be a date considerably later than the date of the last lesson (new or repeated) and consequently could represent more of an 'administrative' record rather than of data strictly useful for our purpose. Therefore, in order to better understand and consequently optimize the functioning of IDL intervention, the collection of the time of each lesson (new and repeated) is necessary.

2) The use of new digital tools

The data produced by and collected from IDL will substantially increase. This not only because we are suggesting collecting new kinds of data, but also because the data will be accumulated over time and, currently, there is an exponential increase in the use of IDL.
This data is potentially precious because it could shed light on many aspects of IDL. It can increase our understanding of its efficacy and consequently allow its optimization. Moreover, in the best case, the use of this data could illuminate some controversial aspects of the problem of dyslexia, and even increase our understanding of our general capacity, as humans, to comprehend and produce language.

Even though the 'manual' and 'static' analysis of this data (such as the analysis to prepare this report), with its dimension and complexity, is still possible and is certainly useful, the use of the latest digital technology such as AI and 'on the fly' analytical tools to perform data related tasks is certainly recommended.
There are four main reasons for this suggestion.
Firstly, artificial intelligence has proved to be a powerful tool to analyse data, with better performance than humans[17]. Secondly, this technology is becoming more accessible and widely used. Thirdly, because of this accessibility, IDL commercial competitors have most probably already started to use AI and other modern digital analytical tools. Finally, as mentioned in the first part of this report, the important and recent growth in the use of IDL has determined a more complex commercial scenario than in the past. The latter can be more easily managed through modern digital technologies.

To summarize, IDL has been confirmed as a valid dyslexia related training solution. However, the software shows important margins of improvement that can be materialized through a more complete collection and analysis of its data, and through investments in modern digital technologies.

[17] AI also complements human abilities.

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