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Apps-olutely Brilliant: Can Technology Improve the Spelling Ability of Primary School Children?

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Spelling is a fundamental aspect of literacy that involves a variety of cognitive processes. Over the years, many methods of teaching spelling have been tried, with varying degrees of success. Since the first computer was introduced in schools, one popular area of debate has been whether using technology is better than using paper for learning skills, including spelling. Much research over the past 20 years has investigated this. More recently, there have been many studies into the use of applications (apps) to assist literacy development. However, as yet no consensus has been reached regarding which method is most beneficial. The present study investigated whether using apps to learn spellings increased performance on a spelling test, compared to using traditional paper methods, amongst 18 children aged 9-10. Results indicate that technology is preferred for many reasons, although using paper is potentially more beneficial due to the effects of memory and motor skills. These findings make a significant contribution to the wider field in that a combination of both paper and technology appears best for teaching cognitive skills such as spelling.

1. Introduction

Spelling, a central aspect of literacy (Ehri 1987), is particularly difficult to master in English, due to the complex grapheme-phoneme correspondence (GPC) and cognitive processes involved. Carney (1997: 13) explains how we have roughly "twenty vowel phonemes" in English but only "five roman *letters* [...] for making up vowel spellings". The five Roman alphabet vowels have more phonemes added to them to create more complicated spellings; an example of this is the English diphthongs, defined by Roach (2009: 17) as a "glide from one vowel to another":

Sound	*Diphthong*	*Possible Spellings*	*Example Words*
p**ay**	/eɪ/	ay, ai	tr**ay**, tr**ai**n
p**ie**	/aɪ/	i, uy, ie, y, igh	h**i**, b**uy**, p**ie**, m**y**, h**igh**
c**ow**	/aʊ/	ow, ou	co**w**, pl**ou**gh
b**oy**	/ɔɪ/	oy, oi	b**oy,** ch**oi**ce
g**o**	/əʊ/	o, ow, oe	g**o**, m**ow**, h**oe**
sh**eer**	/ɪə/	eer, ear	sh**eer**, f**ear**
p**ure**	/ʊə/	ure, ore, oor	p**ur**e, sh**ore**, m**oor**
sq**uare**	/eə/	uare, air, are	sq**uare**, p**ai**r, sh**are**

Table 1. English diphthongs.

1.1. Cognition and spelling

Developmental stage models (Marsh et al. 1980; Gentry 1982; Todd 1982; Frith 1985) highlight the cognitive processes behind spelling, claiming that children learn to spell in stages: e.g. 'logographic' – recognising familiar words, 'alphabetic' – decoding graphemes for known and unknown words, and 'orthographic' – spelling via analogy (Frith 1985).

Lennox and Siegel (1994: 95) also detail a 'developmental shift hypothesis', which states that there is a switch from using 'phonological strategy' to using analogy that occurs at around age ten. These models all correspond to levels of the national curriculum (Table 2) but they are also criticised for not acknowledging the 'information processing demands' involved in spelling (Snowling 1994) and for claiming that spelling via analogy occurs at a much later age than it actually does (Goswami 1986).

Frith (1980)	*Gentry (1981)*	*National Curriculum Level*	*Description of Level*
Logographic	Pre-Communication	1	Children write letter shapes representing parts of a word.
	Pre-Phonetic	2	Spellings are recognisable but not necessarily standard.
Alphabetic	Phonetic	3	Spelling regular and some less common words. Checking for incorrect spellings.
Orthographic	Transitional	4	Common patterns spelt correctly.
	Correct	5	More complex patterns spelt correctly.

Table 2. Theories and levels of spelling development compared (from Montgomery 1997: 20).

Mayer's (2005) Cognitive Theory of Multimedia Learning (CTML) has its basis in three principles surrounding cognition and learning. Firstly, processing information involves both visual and auditory systems – the 'dual-channel assumption' (Mayer 2005: 31). Secondly, both channels are limited in terms of capacity (the 'limited capacity assumption'). Lastly, learning involves coordinating these cognitive processes (the 'active processing assumption'). This theory also assumes that learning can be deepened through a combination of media ('the multimedia principle'), which is something extremely accessible today due to the advances in technology and the ability we have to develop software (e.g. apps).

1.2. Technology supporting spelling

Many studies have explored the use of technology with particular reference to spelling. Cunningham and Stanovich (1990: 485) investigated "the motoric aspects of practising spelling" in children aged six and seven. All children studied words using handwriting, computers and 'letter tiles' and were tested on them after a week. The results suggest that the children learnt more through writing, as the physical action helped them remember the 'correct orthographic patterns' (p. 486). In contrast, Vaughn et al. (1992, 1993) replicated this study with children who had learning disabilities and found no evidence that handwriting has an advantage over using a computer keyboard.

Furthermore, Macarthur et al. (1990) investigated how helpful computers were to independent spelling for children who had learning disabilities. The children used either paper or a computer. They saw "the word, a picture and a sentence" (p. 488) and completed various tasks, including weekly spelling tests. The researchers found an advantage for computers over paper and pencil as the children were more engaged in what they were doing, conflicting with the results found by Cunningham and Stanovich (1990).

Although these studies may seem dated, the question of whether technology or paper is more beneficial in learning spellings is still hotly disputed today, despite technology being more developed and more prevalent in day to day life. Longcamp et al. (2006) taught adults letters from two scripts they were unfamiliar with. The participants used handwriting and technology and then had to see how many characters they could remember. They found that learning the characters by writing assisted with the recognition of the characters, as the act of writing strokes aids the memory of that character, thus supporting results from Cunnigham and Stanovich (1990). This did not happen when typing.

Additionally, Kam et al. (2009) explored the use of games on mobile phones to improve

literacy in India. The games targeted many aspects of literacy, including spelling. A pre-test was conducted, the children used the games for four months and then a post-test was conducted. The researchers found an increase in scores on spellings in the post-test after the children had been using the games. Supporting these results, a study conducted by Smith (2012) investigated the use of iPads across all domains of literacy with 7-8 year-old children. With regards to spelling, she found that students improved between the pre and post-tests. She also reports that 82% of the children believed the iPads helped them with their spellings.

1.2.1. Apps

Recent research in the area of technology has narrowed its focus to investigating the use of apps in lessons. Apps are defined by Hutchinson et al. (2012: 18) as "applications created for digital devices [...] to serve a single, specific function". Falloon (2013) has identified two types of app: those for content consumption and those for content creation. The latter allow users to create their own content (e.g. story boards), enabling them to practice skills that they can then present to others. The former support a 'behaviourist view of learning', the idea of reinforcement through rewards (e.g. virtual sticker charts) for getting answers correct on games and progressing up various levels.

An analysis of the apps available in the educational section of Apple (for use on iPods, iPads and iPhones) conducted by Shuler (2012) found that over 80% are aimed at children, from toddlers to teenagers. Interestingly, Shuler (2012) also found that literacy apps are very few in comparison to other subjects, such as mathematics. Despite this, Hutchinson et al. (2012: 7) claim that the best apps for literacy are those which "allow users to type or write on top of printed text or other backgrounds" and "to record audio for a response". McFarlane (2013) supports this view, highlighting how apps that facilitate knowledge building are the most useful for learning.

1.3. Gender and technology

A further area of debate surrounding learning technology concerns gender. Much research has investigated the idea that males seem to use computers more than females (Kay 2007, 2008) and are less anxious when doing so (Simsek 2011). Shashaani (1997) found that male undergraduates were more confident, and more interested in using computers than females. More recently, Bain and Rice (2006) conducted a similar study with children aged 11-12 and found that gender had no significant impact on attitudes towards technology. They also found that females used computers more and that both genders enjoyed using computers to play games and complete homework.

1.4. The current study

As demonstrated by the literature, there is no definitive answer as to whether technology or paper is more beneficial in assisting with learning spellings. The primary practical rationale behind the study reported here is pedagogic. By investigating the difference between learning spellings on an app versus learning spellings using paper methods, the researcher aimed to find out which one aids children the most. If apps are more beneficial (as some research suggests) then using technology in the classroom to develop this skill is something that should be encouraged. Furthermore, if apps are beneficial to children they could also be beneficial to adults who struggle with literacy.

Both Snowling (1994) and Mayer (2005) highlight the demands spelling places on cognition. If apps could be developed to reduce the cognitive load placed on other domains of writing, the process of spelling could be made much easier. This is a point supported by Dror (2013: 80), who discusses the idea of "cognitive technology" ('offloading' complex mental processes to technology to reduce demands and make more space for other tasks). This process could occur through the development of educational apps. Therefore, by comparing

performance on apps versus paper, this research aimed to highlight the crucial role that apps can play in assisting this fundamental literacy skill. The expectation of the study was that the children will perform better on the computerised spelling test after using an app to learn the words, compared with the paper spelling test where they have learnt the words using a written definition. This premise is built on the idea that multimedia learning facilitates a deeper level of understanding (Mayer 2005).

1.5. Research questions

Q1. Do nine and ten year old children perform better on spelling tests when they have learnt the words using apps as opposed to using paper worksheets?
Q2. Do children prefer to learn new spellings using apps or paper methods, such as reading word definitions?

2. Methodology

2.1. Participants

There were 20 participants (two teachers and 18 children), all of whom were native English speakers from Wiltshire. None of the children had an L2 or any stated learning difficulties. The children's age range (9-10 years) was chosen to replicate previous research (MacArthur et al. 1990; Smith 2012). Children of this age should have a good understanding of the English spelling system, due to the 'developmental shift' (Lennox & Siegel 1994: 95) that occurs at this time. Moreover, they should have knowledge about computers and be able to use a keyboard and apps with little difficulty.

2.2. Equipment and materials

The equipment comprised a tablet computer and charger for the technology tasks (where the child had to watch videos giving definitions of the words from an app), two pairs of headphones, a headphone splitter, and a voice recorder to record the interviews. The materials used were paper task-sheets from which the child had to read a word, a definition and a sentence and write down the key words (see Figure 1).

Finesse:
Sentence: Her finesse as a diver has impressed the other swimmers.
Definition: **Able to do something with skill and style.**

Delectable:
Sentence: This chocolate soufflé is delectable.
Definition: **Delicious.**

Exacerbate:
Sentence: I'm wondering if we should get another car. No, we're already having trouble making ends meet. Another car will just exacerbate the situation.
Definition: **To make a situation worse.**

Figure 1. An example of the paper task-sheet given to the children.

The words chosen for both tasks were selected from the advanced level English section of the app. The app is a British Council resource, used to teach English as a foreign language and to assist learners in passing English exams; therefore, it is pedagogically reliable. The classification of lexis within the app is based on teaching English as a foreign language, meaning that the different levels are accurately categorised into basic, intermediate and advanced. The words used included 'curb', 'row' and 'foggy'. Words that would be unfamiliar were needed so that prior knowledge could be eliminated as an influencing factor.

This was ensured by asking the participants, before they started the tasks, if they recognised any of the words (which they did not).

2.3. The apps

Two 'content consumption' apps (Falloon 2013: 82) were chosen from Microsoft's app store. *English Club* is an app designed by the British Council and has different levels of vocabulary available, from basic to advanced. Within each category, there are three 'volumes' with different words and idiomatic expressions in them. The app allows you to choose a word and reads it out. It then provides a video with a sentence to situate the meaning of the word. Lastly, it repeats the word and provides a written and spoken definition.

Spelling Words allows you to input your own spelling list and record audio to read out the spellings. It also has advanced settings, such as reading the words in a specific order (chosen by the researcher), allowing the children to retry the word if they spelt it incorrectly (which the researcher did not allow, so that the children wrote only one spelling they thought was correct) and showing the correct spelling if it was incorrect.

2.4. Procedure

The 18 children involved in the study were taken out of class two at a time. They were informed that they were taking part in an experiment investigating whether paper or technology is better to support spellings. One child started with the paper tasks (where it was explained to them that they had to read a word, a definition and a sentence and write down the key words) and one child started with the technological tasks (where they were informed they had to watch videos giving definitions of the words from an app). They were also told that at the end of the tasks they would be required to complete a spelling test and then they would change medium.

Once they had completed the tasks, a spelling test was administered to the 'paper' child, whilst the 'technology' child completed a spelling test on the app (where the words were read aloud to them, and they could repeat the word as many times as they liked). Their responses were recorded, by the researcher, on paper. Both spelling tests tested 'retention', which indicates how well people can remember information, and 'transfer', which reflects how an individual uses the information to solve problems (Mayer 2005:32).

Similarly to Vaughn et al,. (1992, 1993), both children were interviewed before going back to class. At the end of the day, the class teachers were also interviewed. These were semi-structured to capture responses relating to technology usage and methods of teaching spellings but also to allow for any interesting and relevant digressions.

2.4.1. Factors that were controlled

In order to ensure that any differences found were due to the different methods of learning being used, as many variables as possible were controlled. The definitions and the sentences for words in context on the app were transcribed and given to the children using paper, following Friedman and Garcia (2011). The main difference was that when using paper the children could write down key words; they could not do this when using technology. Additionally, when using technology, there was a video accompanying each definition.

The order of the tasks was also kept the same. On the app, the written form of the word was presented, a video followed with the sentence and then the definition was read out to the child. Therefore, when using paper, the child's attention was drawn to the written form of the word first, then a sentence and, finally, the definition. Likewise, the order of the words on paper was given to the child in the same order presented on the app. The words on the spelling test app were also read out to the paper child in the same order.

Lastly, the children worked independently on both the paper and the technology tasks, thus eliminating the possibility that any improvement found in spelling tests was due to working

collaboratively with classmates – something that reduces the validity of Falloon's (2013) findings.

2.5. Scoring procedures

The spelling tests for each participant were scored using analysed scoring (Todd 1982). This is because simply scoring the answers as right or wrong would not have provided enough information for detailed analysis. Furthermore, valuable information such as the errors that were made (whether letters were omitted, replaced, etc.) would be lost. This system of scoring involves two separate levels: (1) scoring correct letters, and (2) scoring word order (Todd 1982).

3. Results and discussion

The results from this study did not conform to the expectation that the children would perform better on the computer after using an app to learn the words (see Appendix for raw data). The biggest influence in this study seems to be the method which was used first, not which method was used. When technology was used first, the children performed better on paper. When the paper was used first, the children performed better on technology. Despite this, the children were more engaged with the technology and most reported in the interviews that they preferred using it for various reasons, including time saving and the fact that the word can be repeated multiple times. This supports Wise and Olson's (1994, p.485) claim that computers are ideal for teaching as the speech provided can be repeated often. This was in line with pre-experimental expectations.

3.1. Research questions

Q1. Do nine and ten year old children perform better on spelling tests when they have learnt the words using apps as opposed to using paper worksheets? The results suggest that the children performed better when using paper, regardless of which method they used first. A Wilcoxon Signed-Rank test was performed on this data to compare scores from the same participants on paper versus technology. This is the non-parametric equivalent to the dependent t-test which could not be used as the data was nominal and the sample size was small. This analysis indicates that children performed better when using paper (Mdn = 19) than when using technology (Mdn = 17.25). However, this difference failed to reach significance. Therefore, the method used by the children did not necessarily influence their performance on spelling tests.

The lack of significance between method and spelling score suggests that the medium used first affected the children's performance the most. As there were only a few minutes between each child using both media, the children were familiar with the experiment by the time they used the second medium (whether this was paper or technology) and possibly remembered at least some of the spellings from using the first method. This is a phenomenon known as 'practice effect' (Field 2009) and unfortunately means that the research question remains, in part, unanswered. However, practice effects have huge implications for teaching. Repeated exposure can facilitate learning through subconscious cognitive processes (known as implicit learning (Frensch & Rünger 2003)). By teaching the spellings first on paper and then reinforcing this through the use of technology (or vice versa), performance could be increased due to the memorisation of the spellings from the first method used.

Interestingly, there were four children whose performance was not affected by the medium they used first. One of them used technology first and performed best on technology, the other three used paper first and performed better on paper. This suggests that actually 9-10 year-old children may perform better academically when they have learnt words using paper

and not technology, a finding that contradicts previous research (Garcia 2011; Smith 2012; Falloon 2013).

Q2. Do children prefer to learn new spellings using apps or paper methods, such as reading word definitions? Interview questions were used to establish the preferences of the children and the results show that the majority (n=14) preferred using the apps. This was expected, since nowadays children seem to be very comfortable with technology. Additionally, most (n=13) of the children stated that they felt technology would help them to learn spellings better – a finding consistent with Smith (2012). Answers to the question "Which method would you prefer to use if you were learning spellings in class?" elicited the most interesting responses. The number of participants favouring technology was significantly reduced in comparison to the two preceding questions. The majority (n=14) stated that they preferred technology and that it would be more beneficial, just over half (n=10) stated that they would prefer to use technology in a classroom situation. Furthermore, only two participants favoured the paper session, whereas three children reported that paper would actually help them more in a classroom situation.

Many children stated that being able to use the app to repeat the words and having their spelling and the correct spelling shown to them simultaneously assisted them with learning the spellings. This builds upon the work of Hutchinson et al. (2012), who claimed that apps which let users type and record sounds aid literacy the most, as well as Mitton's (1996) earlier finding that exposure to misspellings facilitates learning. Additionally, Wise and Olson (1994) state that computers are ideal for teaching due to the provision of instant error correction and repeated speech. These are both features of the apps used in the present study and obviously still appeal to users of technology today.

The apps used incorporated both dynamic pictures and spoken words (which could be repeated), something Mayer (2005) claims assists deeper learning. However, paper is also beneficial to learning. Although the 'multimedia principle' (Mayer 2005) facilitates deeper learning, there are also benefits in using just one medium (in the case of paper this is simply written words) because there is less cognitive demand on a person's processing capacity. This could explain why the children in the current study seemed to perform better on spelling tests when they had learnt the words using paper.

The most interesting finding for this question is that some of the children actually felt that a combination of paper and technological methods would help them the most: four felt a combination of methods would be best in a classroom situation. Supporting this is the data gained from interviews with the class teachers. This links to Lankshear et al's. (2000: 24-25) explanation that there are two ways of looking at the influence of technology. Either literacy is "having technology added to it" or new technologies give us "new ways of 'doing' literacy". However it is perceived, incorporating technological methods into teaching literacy skills is something that is potentially beneficial in today's society.

3.3. Gender and technology

The results from this study disagree with previous research. A Mann-Whitney analysis was conducted to highlight any differences between the two genders. This was used instead of an independent t-test, as the data was nominal and the sample size was small. It indicates that females performed better on technology (Mdn = 17.5) than males (Mdn = 16.8), although this difference failed to reach significance. Furthermore, the analysis demonstrates that males performed better on paper (Mdn = 19) than females (Mdn = 18.8), although this too failed to reach significance.

Perhaps the fact that females performed better on technology means they are becoming more confident and equal in terms of technology usage, compared to females almost a decade ago, who had low confidence and limited experience in using computers, particularly when using it to teach (Zhou and Xu, 2007). On the other hand, the statistical analysis for these

results was non-significant, perhaps due to the small sample size, so the fact that the females in this study performed better when using technology and the males performed better when using paper could be purely coincidental.

3.4. Qualitative analysis of individual words

Regardless of which method was used, or which gender performed better, the results show that some words were spelt better than others. 'Delectable' and 'Homogeneous' were amongst the highest scoring words. Contrastingly, 'finesse' was one of the lowest scoring words. This is further illustrated by the individual spellings exhibited by the children for these words. The high score from 'Delectable' can be explained by the transparency of its GPC. This word is spelt how it sounds, so sounding it out phonetically would have produced an accurate, or near accurate spelling. In many of the misspellings, it was the vowels that were incorrect (for example 'delectible' or 'dilectible'), possibly due to the amount of vowel sounds English has (Carney 1997). In contrast, none of the children spelt 'finesse' correctly.

Many spellings given by the children included 'thinas', 'thinesse' and 'finess'. Clearly the initial phoneme presented a problem – a finding explained in part by the fact that the recording of this word was not particularly clear. Additionally, although it was the worst scoring word overall, many of the children identified all of the letters apart from the final 'e'. This word has a transparent GPC, apart from the final 'e' which is silent. Furthermore, the second syllable contains a relatively common letter sequence for English words, apart from the final letter. Perhaps the main reason this was identified by the children is because they used the process of analogy (Marsh et al. 1980; Frith 1985) to spell the word as accurately as possible.

Interestingly, 'homogeneous' was amongst the higher scoring words. The majority of the children were able to spell the first few syllables correctly and many also identified the /ʤ/ sound as a 'g' instead of a 'j'. It is the final syllable of this word that seemed to cause problems. 'Eous' is not a common combination of graphemes in English, at least not for words that 9-10 year-olds would know, therefore they are less likely to be able to use analogy to spell this word successfully.

4. Conclusion

4.1. Limitations

There are a number of limitations in study. Firstly, only 18 participants were used. This means that the results are not generalizable to a wider population. Furthermore, only two teachers from a single school were interviewed, which is not representative as to whether technology usage in schools is common or popular. There were also time limitations. The research was conducted over a two day period, meaning that there was not enough time allowed between the children using both methods. As has already been highlighted, this lack of time led to practice effects (Field 2009) that have clearly influenced the findings of this study and resulted in statistical non-significance, which implies that the findings cannot be generalised and no assumptions can be made about whether technology or paper actually increase performance on spelling tests. Future research should conduct the tests a week apart so that practice effects are reduced.

4.2. Contributions to the wider field

The children involved in this study reported that they liked the apps due to features such as instant error feedback. This lessens the cognitive demand placed on the children, as they do not have to constantly correct their spelling. Furthermore, although not statistically significant, the results suggest (in contrast to previous research) that learning through the use

of paper methods increases performance on spelling tests more than learning through the use of technological methods. This links to the practical rationale of this study and has considerable implications for teaching; using technology alone may not be entirely beneficial. The main contribution this study makes to the field, therefore, is that a combination of both paper methods and technological methods seems to be the most effective way of teaching due to practice effects and the ability to reduce cognitive load (Fiorella & Mayer 2012; Dror 2013). Many of the children stated that a combination of both methods would be best in assisting their spelling development and, although paper will never be redundant, technology is constantly advancing and the benefits it brings to traditional teaching methods should be embraced.

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APPENDIX

Spelling Test scores (participants 1-9, words 1-5)

Participant Number	Age (Years)	Gender	Material (Technology/Paper)*	Acquaintance	Score (/34)	Enamoured	Score (/25)	Homogeneous	Score (/31)	Alumni	Score (/16)	Prerequisite	Score (/34)
1	9	F	**T**	aquatense	19	arnamed	8	omergenees	20	ulovni	8	precrsit	17
			P	aqutance	22	anamard	12	homangenous	25	alumny	14	prerecresite	25
2	9	M	**T**	aquatonses	18	anamer	10	homogeneos	28	elamurny	7	praqusit	16
			P	aqutons	14	inamored	20	homogeneos	28	alommi	10	prequiset	23
3	9	F	T	acquaitance	31	enamoured	25	homoguieness	23	elimini	11	prequisite	28
			P	acquantince	29	enamod	16	homgeuiness	22	elomnigh	12	prerecrosete	22
4	9	F	T	aquantence	25	enamourd	22	houmenginio	10	ulumni	14	preraquiset	26
			P	aquantanis	23	enamoud	19	amoutinges	6	ulumnie	14	rerequset	24
5	9	M	**T**	aquantans	23	anamed	14	homegenios	22	ulamani	11	pryaqune	13
			P	acquanians	23	enamoured	25	homogenious	28	alamanie	13	prerequisit	32
6	9	F	**T**	aqantaens	20	amnanod	4	hamogeneous	28	elamni	11	prerecreset	20
			P	equantanse	23	enamorde	19	homogenease	24	alumni	16	preweqset	15
7	9	F	T	acwtonts	11	ananomoned	12	momogeneous	29	alomoi	10	preracisoit	16
			P	acwantos	14	inamors	10	homojeneouos	28	alomi	10	preloqidit	17
8	10	F	**T**	aquntance	25	inamerd	14	homergenius	22	allumni	15	prewequrasit	26
			P	aquaintance	31	enamerd	16	homoguiness	22	ellomni	11	prewequisit	29
9	10	M	T	aquentance	25	enarmoured	24	homogeniece	20	elomnie	11	preraquesite	28
			P	aquentance	25	enamourd	22	homodimios	14	elomie	7	prequesitie	21

*Here and in the following tables, a bold letter indicates the method used first.

Spelling Test scores (participants 10-18, words 1-5)

Participant Number	Age (Years)	Gender	Material (Technology /Paper)	Acquaintance	Score (/34)	Enamoured	Score (/25)	Homogeneous	Score (/31)	Alumni	Score (/16)	Prerequisite	Score (/34)
10	9	F	T	aquwantans	23	enamerd	16	homergienieous	24	alomnid	13	prewreckwisit	19
			P	oquwatense	17	enhanered	14	homogenios	25	olomnie	11	prewrecwisent	14
11	9	F	**T**	aquatunc	20	anamad	11	homoginios	22	elumni	14	preraqusit	26
			P	aquatuns	17	anamad	11	homogeneos	28	alamnie	13	prequzit	16
12	9	M	**T**	accutaince	22	inamoud	17	homugeneous	28	alumniy	15	preraqusite	28
			P	aquantance	28	enamourd	22	homogenous	28	alumini	15	prerequsite	31
13	9	F	T	aqantintince	20	anamerd	14	homerginess	19	alumlie	13	prerecresite	25
			P	aqantince	22	anamerd	14	homergineas	19	alumlie	13	prerecqusite	31
14	9	F	**T**	acwatos	9	enamot	13	homogeneos	28	olomni	11	prenacusit	18
			P	aquatons	17	enamod	16	homogeneos	28	anlmni	11	prerecuit	20
15	9	M	T	aqantence	22	namored	20	homergenice	17	ilmni	9	prewazacsit	17
			P	aquantence	25	inarmed	12	homaginice	14	ilmni	9	preweqsit	23
16	9	F	**T**	aquntons	17	anamored	20	homojenies	19	alamnie	13	preacwasit	17
			P	acantionce	20	anmored	17	homogenose	21	alamnie	13	prequseit	23
17	9	M	T	equentens	15	anamad	11	homowjenes	22	alumlei	13	preeakset	14
			P	aquatens	17	eamad	8	pomojenios	20	elaire	4	precuewasit	17
18	9	M	T	aceqatnos	11	innamered	17	homogenius	25	illumini	14	prerekrosite	25
			P	aquitance	23	inamered	17	homojenious	25	elumnie	14	prequclosite	25

Spelling Test scores (participants 1-9, words 6-10)

Participant Number	Age (Years)	Gender	Material (Technology /Paper)	Enthralling	Score (/31)	Finesse	Score (/19)	Delectable	Score (/28)	Exacerbate	Score (/28)	Capricious	Score (/28)
1	9	F	**T**	inthrawling	26	thines	12	delectable	28	augsarsterbate	18	curprisous	19
			P	enfrauling	22	finas	11	delectable	28	exsasobate	19	cuprisous	19
2	9	M	**T**	enthraling	28	thinas	9	delectiball	21	exsarsterbate	23	cupreshos	11
			P	enthrolling	28	finnes	14	dilectible	22	exsaserebat	21	cupreshos	11
3	9	F	T	enthrouling	25	finess	17	delectable	28	equsasibate	13	coprisous	19
			P	enthrolling	28	finess	17	delectable	28	ecsassabate	13	copressousious	19
4	9	F	T	enturling	19	thiness	15	dinectible	19	exarsebate	19	copricios	22
			P	entorling	19	finest	14	delectible	25	eacepate	17	copricios	22
5	9	M	**T**	enproring	16	senes	9	delecktabal	24	ecsasabat	12	copisous	14
			P	enfroring	16	finese	16	delectable	28	exasabat	17	coprishois	13
6	9	F	**T**	emthruling	22	phenes	9	delectible	25	exasavat	14	copreshes	10
			P	enthruling	25	thenese	11	deletible	20	exsasabate	16	coprishous	19
7	9	F	T	entholeng	19	cseneious	7	delectable	28	exsarsobate	16	cpresers	6
			P	infalling	18	fines	14	delectobell	20	ucsasoaute	5	copreses	10
8	10	F	**T**	enthraling	28	theness	12	dillectable	25	exasabate	19	cuprisius	17
			P	enforling	16	finnese	16	dillectable	25	exacebate	25	cupriose	11
9	10	M	T	enthrolling	28	fenesse	16	delectable	28	exarsabate	20	capricios	25
			P	enthrorning	22	feneece	10	delectable	28	exasabate	19	corpricios	22

Spelling Test scores (participants 10-18, words 6-10)

Participant Number	Age (Years)	Gender	Material (Technology /Paper)	Enthralling	Score (/31)	Finesse	Score (/19)	Delectable	Score (/28)	Exacerbate	Score (/28)	Capricious	Score (/28)
10	9	F	T	enthrolling	28	finess	17	delectable	28	egsasabate	13	capritious	25
			P	enthrolling	28	thiness	15	delectable	28	eysasobate	13	cupritious	22
11	9	F	T	enflorling	16	fines	14	delectbal	21	egsasabat	11	captrisus	13
			P	enthroling	25	finsse	16	delectaball	23	exatabat	17	coprishos	16
12	9	M	**T**	enthrouling	25	finas	11	delectable	28	exasabate	19	copricous	22
			P	enthralling	31	finasse	16	delectable	28	exacerbate	28	cupricous	22
13	9	F	T	enthaling	23	gineass	15	delicable	22	exsasabayt	14	capicous	19
			P	enthroling	25	finass	14	delicibale	17	exsasabate	16	copricous	22
14	9	F	**T**	emtrolling	20	fenes	11	delectibel	21	ecsersibat	17	cbrishos	7
			P	enflorring	13	fenes	11	delectible	25	ecssabet	8	cabrshos	10
15	9	M	T	infraling	20	sinas	9	denectible	22	-	0	deprishious	20
			P	infraling	20	finus	11	delactible	22	exsapate	13	cobrushes	7
16	9	F	**T**	enthraling	28	thinas	9	delectible	25	ecsasibate	13	crprishos	13
			P	enthraling	28	finess	17	delectible	25	exasibate	19	caprishes	16
17	9	M	T	emcrooling	13	thinas	9	delcebull	13	exasebat	18	cupres	10
			P	enfoling	16	finas	11	delcebal	12	exasbat	15	cupeshos	7
18	9	M	T	infrouling	17	vinese	14	dillectobull	16	exzactobate	20	copressured	9
			P	inthrawling	26	thines	12	dilectible	22	exsasobate	16	copresurse	10