Are children sensitive to typeface design?

An analysis of research (1911–2010)

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Abstract

This dissertation exposes an analysis of a summary of research literature identified between 1911 and 2010 about how or whether children differentiate between typefaces in view of answering the question: Are children sensitive to typeface design? In total, 52 studies were coded and analysed using—formal & informal—meta-analysis procedures. The results from the analysis of the fifty-two coded studies show that children are moderately sensitive to typeface design relative to the three dimensions of sensitivity; performance, comprehension and preference, with preference being the most affected dimension. The results have also demonstrated that children aged 4–7 are the most sensitive to the three dimension of sensitivity; performance, comprehension and preference. In addition, the results also demonstrate that more research is needed in the areas of spacing and layout as typographic factors, as well as in the investigation of the role of age and sex with regards to the three dimensions of sensitivity.

"Far better an appropriate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise." J.W. Turkey, 1963

Table of contents

Table of figures

Introduction

When considering the subject of children and typeface design a number of question can be formulated. For example: Should typefaces for children look like children's handwriting? Do children need specially designed typefaces? Are children aware that there are *different kinds* of typefaces? Do children have a preference for the books they choose to read based on the type design employed? These are some of the questions ignited when considering children and typeface design.

There has been an on-going discussion regarding children and typography in various disciplines—education, psychology and communications design to name a few—and unfortunately, some of it is not founded in empirical studies. This dissertation aims to address the question of how or whether children are sensitive to typeface design. Why is this a relevant question? Children are exposed to type design from a very young age—on screens, in books, while playing games, in fact everywhere—and if children's access to knowledge and understanding their environment can be motivated by the form in which it is presented, this could only be of benefit.

This summary of research literature and the results of the research carried out and exposed in this dissertation will benefit type designers, typographers, graphic designers, teachers, researchers, publishers of children's materials and for that matter anyone who has an interest in children and typography. It may also help to shape future efforts of studies considering children and typeface design.

The main objectives of this study were to survey literature and research from 1911 until 2010 about how or whether children differentiate between typefaces; to define a set of criteria for use in analysis of the literature and research selected; to draw a conclusion in response to the question: Are children sensitive to typeface design?

1 Context

1.1 Overview

There is certainly an awareness that children's books look different from those of adults, but how often does it consciously come to mind that children's books might be specially designed for their needs, preferences and supposed cognitive capacities in terms of format, illustrations used, language, typography and typeface design for example. It is this last mentioned area of typeface design that this dissertation focuses upon.

Naej, a typeface project—which developed into a typeface for use in children's recreational books undertaken from October 2010 to June 2011 at the University of Reading by Blondina Elms Pastel—brought to the forefront the awareness of the many controversial discussions concerning children and typography that have taken place over the years. During research on the Naej project, a recent and major study on children and typography was identified and consulted; it was the Typographic Design for Children Project.

Work done by the Typographic Design for Children project based in the Department of Typography & Graphic Communications at the University of Reading (1999–2005) has suggested that children read serif and sans serif typefaces equally well, and other researchers seem to agree. Sassoon (1993, p.161), in *Through the eyes of a child* —

Perception and type, notes agreement with Valerie Yule, stating that there is little research if any that proves a majority of children have difficulty discriminating between written letterforms and typographic letterforms. Similarly, Coghill's (1980) research also appears to indicate that children are not as sensitive to letter shapes as it might be imagined. Additionally, a study conducted by Thiessen (2010)—focused on dyslexic children—seems also to argue that it might be more productive to look at how type is set for children rather than having a 'specifically designed typeface' that meets child specific needs.

However, teachers, seem to have another point of view. As a preliminary study to Coghill's (1980) research, which focused on finding out if early readers are able to read familiar words set in unfamiliar types, fifty teachers were requested via a questionnaire devised by Coghill to assess typefaces as being suitable or unsuitable for early readers. Coghill (1980, p.254) reported:

> All but one teacher thought the sans serif was suitable, thirty-five thought the sans serif was the only one suitable for early readers and twenty-six indicated in their comment that this was, in part, because it resembled children's handwriting.

Birdie Raban apparently reported similar results. Conducted in 1984, Raban's study surveyed 271 teachers to find out what factors the teachers deemed as important for choosing books for young children.

> Two-thirds of the 271 teachers in her sample favoured the use of sans serif type throughout the infant school because they thought that clean, clear shapes corresponded closely with children's handwriting. These teachers also preferred infant a's and g's in books for five-and six-year old children, but thought this was less important for seven-year olds and above" (as cited by Walker, 2005).

Nevertheless, there is little or no research supporting teachers' viewpoint on this matter of children and typography. Teachers often recommend the use of sans serif typefaces and the use of infant characters. Why is this? Do teachers have tacit knowledge that can help researchers, type designers, and typographers in their demarches?

Others—psychologists, ophthalmologists—have also done their share of research. In fact, the well-know French ophthalmologist, Émile Javal is the first to have conducted empirical research in the domain of typography for children. Javal and his associates have lead the way for improved school hygiene, and for future research on legibility of print and eye movements in relation to reading (Renonciat, 2005; Sanford, 1888; Tinker, 1927).

These aforementioned views and arguments have led to the main point in question of this dissertation: Are children sensitive to typeface design? The analysis of literature and research done from 1911–2010 in trying to answer this question will also provide a summary of research for consultation by designers, educators, researchers and others interested in this field of study.

1.2 Method

Why meta-analysis?

There are varying methods of integrating findings across studies; the method this dissertation has used is *meta-analysis,* a term coined by Gene Glass (Hunter, Schmidt, & Jackson, 1982). Meta-analysis has been recognised not just as a new way of conducting reviews of research literature—integrating research findings and exposing trends—, but more as a new way of thinking about accumulated research data (Hunter & Schmidt, 1990).

In an article in the *American Psychologist*, Schmidt (1992) states that meta-analysis has shown that analysis using traditional methods of

statistical significances tests and the null hypothesis do not aid in the development of cumulative knowledge. According to Schmidt (1992), the data generated by a single study is insufficient to command any authority and Schmidt furthermore advises that the data received from primary studies is distorted or warped, and in order to see what the data is *really* conveying meta-analysis must be conducted (Hunter et al., 1982).

Also, as a final note on the benefits of using meta-analysis, Schmidt (1992) indicates that meta-analysis is not singularly used as a device to expose cumulative knowledge but also:

> … prevents the diversion of valuable research resources into truly unneeded research studies.

For example, consider the quantity of legibility studies that have been conducted to date, yet, there are no specific conclusions or clarifications of theories on the matter of legibility (Lund, 1999). Thiessen (2010) in her thesis, *Using visual explanations of complex verbal concepts to aid dyslexic children in literacy acquisition,* also seems to have concluded that this issue has not yet been solved and suggests that more knowledge of the influence of typography on legibility is needed. Hence, perhaps the next step may be to conduct meta-analyses summarizing the numerous studies on legibility rather than conducting another legibility study to add to the existing collection.

However, there is no lack in the criticisms of meta-analysis. One of the most frequent arguments, which was encountered first hand on consultation with a member of the Statistical advisory service at the University of Reading, is that a study comparing apples with oranges would be meaningless, unreliable and irrelevant (Hunter & Schmidt, 1990).

Hunter & Schmidt (1990) present two counterarguments with regard to the misconceived criticisms that mixing apples and oranges produces irrelevant results. Firstly, meta-analysis analyses research

results—numerical results—and Hunter & Schmidt (1990) put forward that if there is a meaningful way to associate numbers within different studies, then there will be meaningful ways to compare those numbers. Secondly, whether study results differ across settings is an empirical question and Hunter & Schmidt (1990) advise that discovering whether potential moderator variables are in fact actual moderator variables would be impossible to answer without some kind of meta-analysis (a critic of this argument can be found in Hunter & Schmidt, 1990, p. 518-521).

There are different approaches to meta-analysis and as this dissertation is focusing on studies where artefacts—human experimental errors—are not homogeneous across studies the methods presented by Hunter et al. (1982) and Hunter and Schmidt (1990) seemed to be the appropriate methods to apply as these methods first focus on adjusting and correcting study artefacts to achieve an accurate estimate of the dependent variables overall before the meta-analysis of correlations is conducted.

As a consequence of the sparse data that was usable from the coded studies for the *formal* meta-analysis, *informal* meta-analyses—quantitative analyses—were conducted across the studies coded.

Identification of literature and research

Typeface design is an integral part of typography—there can be no typography without typeface design—and therefore, studies apart from those that looked specifically at typeface design were also considered for analysis. The research literature analysed in this dissertation present a variety of methods and rationales. The approach this survey took, was that of including all identifiable research and literature that contained an emphasis on typography related to children's needs. In other words, the selection of research literature was not based on any pre-assessment or criteria driven inclusion directive. Nevertheless, priority has been given to works that have been published.

The research and literature summarized in this project were identified from a variety of sources: through citations in related studies, bibliographies of research reports, abstract lists, electronic databases including: Wiley, Jstor, Medline, Worldcat, Articlefirst, using "typography for children" as keywords, and a continuous examination of several journals particularly likely to have published evaluations on this subject for example, *Journal of Research in Reading*, *Journal of Typographic Research* and *American Journal of Psychology*. It is important to note that database search did not identify most of the research and literature obtained for use in this dissertation, and it was in analysing reference lists that a majority of the research literature was identified. This reveals an issue that plagues typographic research, which is that typographic research studies are being conducted in various disciplines and some disciplines do not categorise their research as typographic even if it involves typographic factors as variables; which means this work even though relevant will not appear in search request.

1.3 Typography and children from the 18th century

Once upon a time, children did not learn to read and write at the same time. Quite unlike today, in England in the seventeenth century children learned to read before they learned to write (Darnton, 1998). This teaching of reading and writing as a pair is in fact the bedrock of one of the main arguments concerning children and typography even today. Teachers argue that typefaces children learn to read should be similar in appearance to those used in teaching them to write, reasoning being, the teachers claim, that it could help children's learning capacity (Walker, 2003). Could this be true? Zachrisson (1965) suggests that the forms that a child is using in learning to write, is a good enough reason that a similar form of letter should be used in early reading exercises. Furthermore, Coghill (1980) has reckoned that

Figure 1.1 Le bureau tipographique of Louis Dumas. In this image, Dumas and his wife are teaching the children of France how to use the bureau tipographique. (http://www.inrp.fr/she/lej/liste_1_az.htm).

the use of sans serif type in children's reading books seems to have nothing to do with the question of what is most legible but rather is more related to writing.

Reading and writing are they not two very different skills? When a child learns to write they write letter by letter; learning to write can be considered situated primarily in the psychomotor domain (Bloom, 1956). It seems that whether learning to write or already having the skill of writing it can only be done one way, which is letter by letter. On the other hand reading—a skill primarily of the cognitive domain (Bloom, 1956)—is about making sense of words and phrases (British Association, 1913). In the *Report on the influence of school-books upon eyesight* issued by the British Association for Advancement of Science (1913), it is suggested that a typeface that is suitable for isolated letterforms is not necessarily the best suitable for "word-wholes". Learning to write consists of learning to recognise and make shapes of individual letterforms; on the contrary the process of reading involves the recognition of word-wholes (British Association, 1913).

In France, since the early eighteenth century there was already a sparking interest in children and typography. Louis Dumas a French educator, deeply concerned by the methods employed to teach children how to read and write invented *le bureau tipographique* (Figure 1.1). Dumas, in the 1730's, prescribes that children from 2 years of age should begin to familiarise themselves with type; at this age in France children were taught to recognise capital letters. The British Association (1913) seems to have come to a similar conclusion from their selected committee. Concerning the matter of children learning to read, the committee suggested that is preferable to postpone the use of books as long as possible while using other methods of instruction that can be easily seen at a distance. It must however be noted that Dumas' initiative was that of creating a pleasurable experience for the children to incite them to discover their environment (Grandière,

1999) where as the committee was concerned with reducing strain on children's eyes (British Association, 1913).

In France this interest in children and typography led to the introduction of a printing press at the school of Célestin Feinet in 1924. In this case, according to Renonciat (2005), this was an initiation of the child printer.

At the turn of the nineteenth century France still lead the way. Emile Javal a French ophthalmologist conducted the first experimental research in legibility (Renonciat 2005; Tinker, 1927). Like Dumas, his concern was for children having to contend with reading books from a very young age. Similarly to Javal's point of view, Hughes and Wilkins (2000) pointed out that in reading schemes children had to struggle with the increase of complexity of visual content, referring to the systematic decrease in size of text as the age of the child increased.

Following Javal's observations the Ministry of education in France set up a committee, which eventually confirmed Javal's findings (Renonciat 2005). Following this, in 1982 another committee was established to reform typography implemented in schoolbooks. One of the reforms recommended by the committee was that letterforms that are easy to identify and easy to differentiate should be employed in schoolbooks (Renonciat 2005).

Javal's work was quickly recognised in England. Beginning with Shaw (1902) and his literature on school hygiene. In 1911, the *British Association* for the Advancement of Science appointed a committee at Portsmouth to inquire into the influence of schoolbooks upon eyesight (Hartley and Rooum, 1983). The committee did not forget to mention that their inspiration came from Javal's work (British Association, 1913). Apparently, the report published in 1913 was a revision of the report presented by the committee in 1912 involving substantial alterations (British Association, 1913).

The section on typography in the 1913 report included the contributions of type founders, printers, oculists, directors of education,

teachers, publishers and school medical officers (British Association, 1913). One of the points addressed by the committee and sent out to the Education authorities was:

> What regulations (if any) have been adopted for the selection of schoolbooks and atlases (including limits of price, size of type, character of illustrations, weight, &c.)…(British Association, 1913).

From the replies received from sixty authorities, the committee formulated that:

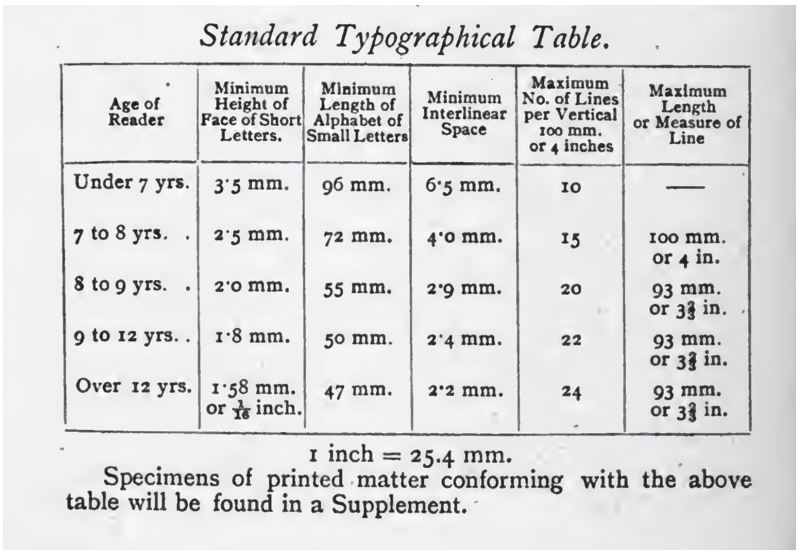
> … no definite principles or rules as to printing and other conditions of legibility have been adopted in the selection of schoolbooks … (British Association, 1913).

Nevertheless, replies also implied that officers responsible for book-supply did pay attention to type amongst other things, while others replies indicated it was the teachers who were responsible for textbook selection (British Association, 1913). The 1911 committee finally concluding that there was no methodical practice involved in schoolbook selection (British Association, 1913).

The recommendations presented by the British Association (1913) were for a very long time the authority in Europe (Renonciat 2005). Among the factors that were taken in to consideration by the committee were; the character of the type, the size of the type, line spacing, letter spacing, and the measure (line length). It must be noted that these were last on the list of factors even though it cannot be confirmed there is a relation of significance of factors relative to their placement in the list. However, the committee does states that

> The size of the type-face is the most important factor in the influence of books upon vision (British Association, 1913).

The committee designed the *Standard Typographical Table* as a recommendation for implementation in schoolbooks (Figure 1.2). The size of the typeface and line space decreasing as the age of the child increases. However, Hughes and Wilkins (2000) criticises this method of decreasing typeface size and line spacing as still implemented in reading schemes today. Hughes and Wilkins (2000) state that as the age of the child increases the content (linguistic and semantic) of reading material becomes more complex and it will only be a burden on the child to increase the complexity of the visual aspects of the reading material; in this case, decreasing type size and line spacing.



Standard Typographical Table.

Age of Reader	Minimum Height of Face of Short Letters.	Minimum Length of Alphabet of Small Letters	Minimum Interlinear Space	Maximum No. of Lines per Vertical 100 mm. or 4 inches	Maximum Length or Measure of Line
Under 7 yrs.	3·5 mm.	96 mm.	6·5 mm.	10	—
7 to 8 yrs. .	2·5 mm.	72 mm.	4·0 mm.	15	100 mm. or 4 in.
8 to 9 yrs. .	2·0 mm.	55 mm.	2·9 mm.	20	93 mm. or 3⅔ in.
9 to 12 yrs. .	1·8 mm.	50 mm.	2·4 mm.	22	93 mm. or 3⅔ in.
Over 12 yrs.	1·58 mm. or 1/16 inch.	47 mm.	2·2 mm.	24	93 mm. or 3⅔ in.

1 inch = 25.4 mm.

Specimens of printed matter conforming with the above table will be found in a Supplement.

Figure 1.2
The Standard typographical table established for use in schoolbooks. (British Association, 1913)

Simultaneously, in America the *Association for school hygiene* published their first studies in 1911. This work was followed up in the 1920's by Blackhurst and then continued by Tinker who did a notable amount of research on the legibility of typography and the issues of typography used in schoolbooks (Betts, 1949; Patterson & Tinker, 1929; Renonciat, 2005; Watts & Nisbet, 1974).

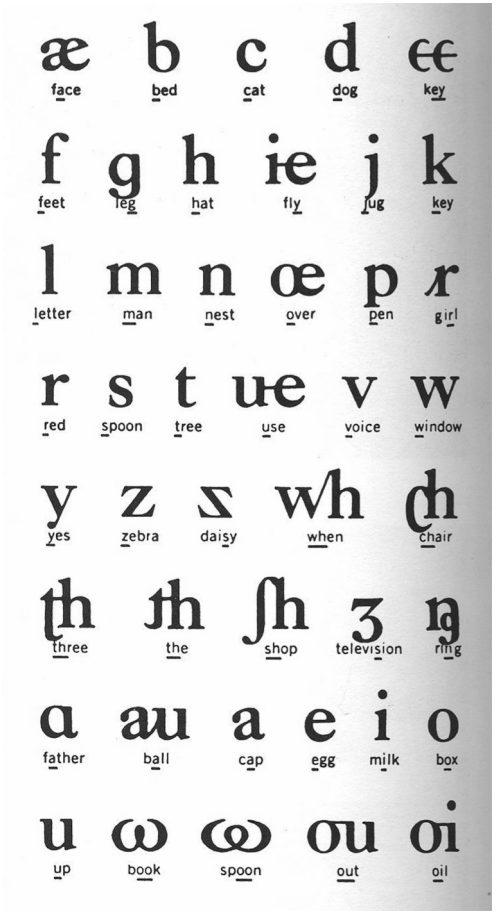


Figure 1.3 The Initial teaching alphabet. Developed in England in the1960's by Sir James Pitman (Spencer, 1968).

The cat sat on the mat.
The dog slept in the house.
Does this red hat belong to Benny?

abcdefghijklmnopqrstuvwxyz
ABCDEFGHIJKLMNOPQRSTUVWXYZ

Figure 1.4 The first type family designed specially with children in mind; Sassoon Primary.

On subject of letterforms specifically designed for children, it has been suggested by Makita (1969) that children learning to read Oriental forms have far less reading problems compared to children who read roman letterforms. Makita (1969), a Japanese psychiatrist, implies that this may be in fact due to problems in the characteristics of the Latin alphabet. In 1960 an alternate alphabet the *Initial Teaching Alphabet* also know as i.t.a. (Figure 1.3) was developed by Sir James Pitman, it was designed to aid the learning of reading but this experiment proved to be unsuccessful and is not taught in schools today (Montague, 1970; Sassoon, 1988). Then in 1980, also in Britain, Rosemary Sassoon designed Sassoon Primary (Figure 1.4) the first type family developed with the problematic of early readers in mind (Sassoon, 1993).

In Britain, the interest in typography and children remains active. At the Department of Typography & Graphic Communications at the University of Reading, the Typographic Design for Children project was set up in 1999, and focused on many issues dealing with typography and children such as; letterform, legibility, spacing and type size both on screen and in print. This project led to recommendations for designers, teachers and publishers (Walker, 1992, 2005).

With all of these studies there is still no conclusion on the matter of legibility (Lund, 1999). Watts and Nisbet (1974) suggest that they are no precise rules to follow on what will produce typographic perfection for children's books, however, Walker (1992), suggests that some typefaces serve their function better in children's books than others and gives recommendations on the subject.

2 Analysis of research

2.1 Review of empirical research

In this section, the dissertation has dealt with analysing the research literature from the selected period of 1911 until 2010 about how or whether children differentiate between typefaces. There was no specific strategy adopted for selecting those studies exposed in some detail in this section. Due to the limitations of this Master dissertation—both in time and word count—a general overview of findings was given about the research literature—the earliest empirical research investigated was from 1923—concerning how or whether children differentiate between typefaces (see Appendix A for list of studies identified). There were some matters that seemed important to develop in greater detail and only these matters were developed in a more explicit discussion.

Research design

In analysing the research literature between 1911 until 2010 about how or whether children differentiate between typefaces, it was found that the recording of the research design methods and procedures needed to be more explicit. When comparing the more recent studies to the earlier empirical investigations, it appears that the earlier studies were more rigorous with registering the research methods and procedures.

For example, it was found that the logging of Zachrisson's research was thorough and nothing was left to assumption.

In addition, it was found that researchers needed to be more systematic with regards to the data being coded in their research. The research report of Hughes & Wilkins (2000) state that their investigation was to discover whether the layout in two popular children's reading schemes was suitable for intended ages. The description in the reports findings of Hughes & Wilkins (2000) appears to report on decrease of text size and not on spacing, yet, Hughes & Wilkins (2000) conclude:

> … these results suggests that reading speed and accuracy could be increased by presenting children with a text having a larger, more widely spaced, typeface.

It was also found that some researchers who conducted multiple studies at a time reported for example "passages from the previous study were used". It seems that this implies the researcher did not guard against multiplying artefacts and is taking for granted that consultation of a previous study might not be possible. Hence, this practice may render the consulted study impracticable in some instances. Therefore, the description of the methods and procedures employed in the research should be methodological so that nothing is left to assumption of consulting researchers or interested parties.

In some of the research investigations employing the measure of miscue analysis—the recommend length of the passage by Campbell as cited by Reynolds & Walker (2004) for miscue analysis should be 300 to 500 words—recommended properties for test validity were not adhered to. An example of this is found in the research reports of Reynolds & Walker (2004) and Walker & Reynolds (2003). Even though for these two studies the total number of combined words fell in the range, these studies used passages significantly far from the recommended passage length.

On another issue, it is well known that point size with reference to type does not give any exact information on the actual height or width of a letterform. Although some researchers employed an x-height in millimetres as the measurement of type size in their investigations, it did not guarantee an equivalent type size for each typeface involved. However, Zachrisson's (1965) proposition of *visual size* appears to be a more precise calculation. The concept of visual size was introduced in Zachrisson's 1954 experiment 4 (study 25a) on type that investigated if there was any difference between sans serif and old face types. Zachrisson (1956) stated that visual size is the expression of the product of the x-height measured in mm, by the mean width of the letters, also in millimetres, resulting in a mean surface extension per letter in millimetres squared. This means that letterforms being compared in an investigation on type would occupy approximately the same area making their comparison more valid.

Discrepancies were also found in the coded information of some research. An example of this is in the Wilkins et al. (2009) research report where the age group of the participants coded suggests two different age groups of participants; the second study conducted by Wilkins et al. (2009) is referred to in this instance. The study reports "a class of children in Year 3" participated in the study; Year 3 children would indicate that the age range is from 7–8, where as, Wilkins et al. (2009) further report that the children were "aged 8:1–9:6" which would identify them with a Year 4 and Year 5 class.

Wilkins et al. (2009) second study, reported that for the conventional edition of the test used in the study the reading age measured was 7:8 and for the constant size edition of the test the reading age measured was 8:1; approximately 4 months difference between the two test editions. The question that came to mind is the following: Are these results reflecting participants results of Year 3, Year 4 or Year 5 children? Consequently, the validity of the research may be put into question by such inconsistencies.

Age groups

In addition, and of much importance it seems, these age ranges incorrectly coded in the Wilkins et al. (2009) research literature, identify with age ranges of children who exhibit rapid gains in eye-movement efficiency, according to F. A. Ballantine. In 1931, Ballantine discovered that from second grade through to fourth grade reading habits of children are developing quickly, as cited by Tinker (1965) (see Appendix C for school age conversions). Buswell, (1922) also found that by the end of fourth grade eye-movement patterns were stabilizing (see Figure 2.1), which means these fourth grade children are beginning to react or are reacting like adult readers do to typographic stimuli.

TABLE XXIV

GRADE MEDIANS FOR EYE-MOVEMENTS IN ORAL READING

	I B	I A	II	III	IV	V	VI	VII	F	So	J	Se	Col
Average number of fixations per line	16.0	14.5	12.0	10.4	10.3	8.7	8.9	8.7	9.1	8.3	8.0	9.3	8.4
Average duration of fixations.....	19.2	12.8	9.8	10.1	7.7	7.2	7.3	7.0	6.7	6.6	7.0	6.5	7.5
Average number of regressive movements per line..	4.4	3.1	2.5	1.8	2.0	1.4	1.4	2.0	1.5	1.5	1.1	1.4	1.2

Figure 2.1
Exhibits grade medians for the three types of eye-movement habits in oral reading. (Buswell, 1922)

In the second study of Wilkins et al. (2009), the mean age of the participating children was reported to be 8:9 which indicates that sixteen children—half of the participants in the study—are tending towards age 9–10, this coincides with fourth grade children. The Salford Sentence Reading Test (Revised) appears to be designed for children in the 5^{+}–10^{+} age range, which means that half the participants in the second study of Wilkins et al. (2009) were at the exiting end,

which also coincides with the age—9–10—where oculomotor patterns are stabilizing. Tinker (1965) concludes and suggests from the studies of Ballantine and Buswell, that since eye-movement behaviour signifies degree of proficiency in reading mechanics, it may be put forward that from around fourth grade the mechanics of reading is tending towards that of adults. This implies that the results from the second study of Wilkins et al. (2009) may not be applicable for Year 1 to Year 3 students using the Salford Sentence Reading Test (Revised) or to children who are still developing reading habits.

Concerning age, the only study in the fifty-two coded studies in this dissertation that addressed the idea that it is particularly those children prior to fourth grade —ages 5–8—that need to be investigated due to their immaturities in oculomotor patterns is the study conducted by Woods, Davis, Scharff, & Austin (2005). Another study where age was considered was the study reported by Wagner & Harris (1994), which looked particularly at whether and how the effects of typeface characteristics change with subject age. The research of Wagner & Harris (1994) showed that for fourth graders the balance of hemispheric processing in letter identification was sensitive to typefaces. This study revealed that there is a Right Visual Field advantage for simple type forms—in this case Standard Medium, a sans serif face—and for more complex type forms—Old English in this case—there was a Left Visual Field advantage. It is thought that hemisphere specialization increases with development; Wagner & Harris (1994) cite Levin stating that a Left Visual Field advantage emerges at age 10; this would imply that children younger than age 10 display a Right Visual Field advantage which is sensitive to simple forms.

Continuing on age related studies, Asso & Wykes (1971) concluded from their investigation on discrimination of spatial confusable letters by young children that accuracy of b,d,p,q,u and n depended on the methods of teaching employed; naming the

confusable letters was one of the most difficult tasks to perform by the children—aged 5–6—investigated. These results appear to align with Levine's findings as cited by Wagner & Harris (1994) that a Left Visual field advantage emerges at the age of 10. Apparently, the left hemisphere develops a specialization for letter naming whereas the right hemisphere a specialisation for spatial processing (Wagner & Harris, 1994).

Another study that considered age, is the research conducted by Weiss (1982), which investigated if there are differences in the consideration of the importance of type in book selection with regards to age and sex.

Cues in word recognition studies also looked at the impact of age on test results; for example the study done on first graders, third graders and college students by Fisher and Price (1970) suggests that overall, letter cues were used more frequently than shape cues. Fisher and Price (1970) found there was a reduction in the use of shape cues as reading ability developed; this would tend to coincide with increase in age. This study found that the youngest children used the first letter of a word more. Marchbanks and Levin (1965) confirm that the first letter was the most used cue between 5–7 year old children, however they found that with kindergarten boys there was a competition between the first and last letters in word recognition more often basing their judgement on the last letter.

Surveys

Surveys are by nature subjective, the survey questions—for example Reynolds et al., (2006)—of asking children which text is easier to read or which text is more difficult is rather idiosyncratic (this was clearly observed by some of the responses given by the children surveyed across the fifty-two studies consulted for this dissertation to such questions) and the information obtained from such questions seems only relevant to the sample tested. Furthermore: What does more

difficult or easier mean to the child being asked these questions? Does the interpreted meaning match that of the researcher presenting the question? Children have different backgrounds and their perceptions will be different and therefore may each interpret the question differently. It is believed a methodical approach would yield results that might be more comparable. It is thought that preference data could be gathered by establishing a list of predefined answers, like a multiple choice, this would mean that children are all choosing from a similar collection of responses and the researcher does not have to interpret the child's response.

Gender

Although some research studies investigated in this dissertation registered the amount of girls and boys as participants in their studies, the majority of researchers from the fifty-two studies investigated did not seem to think that the gender factor was relevant, as sex was little explored. The research literature of Reynolds et al. (2006) for example state that 6 children could not see any differences between the two extreme line spacing test and 10 could see differences between the two extreme versions when shown together, a further question that might have been investigated to enhance general knowledge is; What part of these children were girls and what part boys? There are reading material specially designed for boys and those specially designed for girls and an answer to this question could only benefit. In Coghill's (1980) research it was reported that boys commented at length on the type. Does this mean that boys are more sensitive? This question is left unanswered due to a lack of investigation in the area of gender. Zachrisson (1965) and Blackhurst (1923) also exhibited some attention to gender in their research literature.

Do methods of instruction play a role in how children relate to type?
It well accepted that young children have difficulty with letters that have reversed spatial orientation, horizontal reversals being more difficult DiMeo (1969). The studies on the question of why do children reverse letters by Frith (1971) suggested a theory, which seems to be of some importance to the type designer. Based on the findings of these studies, Frith (1971) suggests that the well-know reversal errors for letters, p and q, and b and d occur perhaps not because of a lack in the ability of the child to discriminate but rather due to a lack of bias for one particular orientation for the basis shape. Frith (1971) puts forward that because the spatial orientations of b,d,p,q are encountered equally often by the child no preference to special orientation is established. Frith's results show that the Year 1 children made errors due to a strong preference for the spatial orientation they were familiar with where as for the children age 3–4 their errors were not due to any bias as they were unfamiliar with the shapes presented.

Deich's (1971) study results appear to agree with the theory of Frith (1971) mentioned in the previous paragraph. The results from the research of Deich (1971) investigating 120 children ranging from age seven to age fourteen demonstrate that as age increased the relative difficulty of reading inverted rather than upright words increased. For one group of the lowest grade—second grade—thirteen of twenty subjects were able to read the inverted words nearly as fast as the upright words compared to zero subjects in a group of 20 eighth graders.

Likewise, a study by Williams & Ackerman (1971) also appears to support the argument by Frith (1971) which is, that perhaps because the b, d, p, q combinations are met equally often no preference for spatial orientation is made. This brings into question what methods of training are most effective for efficient letter discrimination. The study of Williams & Ackerman (1971) suggests that for first grade children, ages 6–7, successive discrimination training—where the subject will see

only one spatial orientation at a time—rather than simultaneous discrimination training—where subjects experience similar bases forms of which differentiations are less easily detected—is the more suitable training method.

An experiment conducted by Hinds & Dodds (1968) shows the teaching method, Words in Colours, had significant effects on beginner readers'—age 5–6—ability in word recognition. Perhaps these techniques in colour could be used with regards to the b,d,p,q spatial orientation difficulties.

Why is this information important for the type designer? As these forms are very similar in basis shape, the more discriminability factors built in the letterform the more help would the young reader have in letter discrimination. However, the type designer should be aware that they can only do so much without disrupting the standardized shapes of the alphabet and it seems that the method of instruction that children receive plays a vital role in how children relate to letterforms. (Some of Zachrisson's (1965) experiments showed significant results between instructional groups.)

Table 1: Studies surveyed

* SDim = Sensitivity dimension Pe = Performance C = Comprehension Pr = Preference

Study	SDim*			Year	Title	Author(s)
1	Pe	C	Pr	2009	Typography for children may be inappropriately designed.	Arnold Wilkins, Roanna Cleave, Nicola Grayson and Louise Wilson.
2		C	Pr	2006	Children's responses to line spacing in early reading books or 'Holes to tell which line you're on'.	Linda Reynolds, Sue Walker and Alison Duncan.
3	Pe	C	Pr	2004	'You can't see what the words say': word spacing and letter spacing in children's reading books.	Linda Reynolds and Sue Walker
4	Pe	C	Pr	2003	Serifs, sans serifs and infant characters in children's reading books.	Sue Walker and Linda Reynolds.
5	Pe	C	Pr	2002	Reading at a distance: Implications for the design of text in children's big books.	Laura E. Hughes and Arnold J. Wilkins
6		C		2001	Effects of typeface and font size on legibility for children.	Rebecca J. Woods, Kristi Davis and Lauren F. V. Scharff.
7	Pe	C		2000	Typography in children's reading schemes may be suboptimal: Evidence from measures of reading rate.	Laura E. Hughes and Arnold J. Wilkins.
8	Pe			1994	Effects of typeface characteristics on visual field asymmetries of letter identification in children and adults	Nancy M. Wagner and Lauren Julius Harris.

Table 1: Studies surveyed

* SDim = Sensitivity dimension Pe = Performance C = Comprehension Pr = Preference

Study	SDim*			Year	Title	Author(s)
9		C		1993	Do print size and line length affect children's reading comprehension?	Averill J. Archer and Warwick B. Elley.
10	Pe	C		1993	Performance differences between Times and Helvetica in a reading task.	Rudi W. De Lange, Hendry L. Esterhuizen and Derek Beatty.
11			Pr	1993	Through the eyes of a child—Perception and type design	Rosemary Sassoon
12		C		1991	What children see affect how they read.	Piers Cornelissen, Lynette Bradley, Sue Fowler and John Stein.
13	Pe	C		1982	Text display effects on the fluency of young readers	Bridie Raban
14		C	Pr	1982	Children's preferences for format factors in books.	Maria J. Weiss.
15		C		1980	Can children read familiar words set in unfamiliar type?	Vera Coghill.
16		C		1971	Discrimination od spatially confusable letters by young children.	Doreen Asso and Maria Wyke
17		C		1971	Why do children reverse letters?	Uta Frith
18		C		1971	Children's perception of differently oriented shapes: word recognition.	Ruth F. Deich

Table 1: Studies surveyed

* SDim = Sensitivity dimension Pe = Performance C = Comprehension Pr = Preference

Study	SDim*	Year	Title	Author(s)
19	C	1971	Simultaneous and successive discrimination of similar letters.	Joanna P. Williams and Margaret D. Ackerman
20	C	1970	Cues to word similarity used by children and adults: supplementary report.	Virginia Lee Fisher and Jill H. Price
21	C	1970	Role of letter-position cues in learning to read words.	Calvin F. Nodine and James V. Hardt.
22	C	1970	Cues used in visual word recognition.	Joanna P. Williams, Ellen L. Blumberg and David V. Williams
23	C	1965	Cues by which children recognize words.	Gabrielle Marchbanks and Harry Levin.
24	Pe C Pr	1954,56	Studies in the legibility of print.	Bror. Zachrisson.
25	Pe C	1927	Investigations in the Hygiene of reading.	J. H. Blackhurst.
26	Pe	1923	The effect of reading changes on type size.	A. R. Gilliland.

2.2 Identification of research factors

In this section, the dissertation has dealt with outlining and defining terminology and factors that will be employed in analysing the data collected from the selected studies (see Table 1) of the research literature from the period of 1911 until 2010 about how or whether children differentiate between typefaces.

Dimensions of sensitivity

Researchers have used a variety of measures to assess children's sensitivity—cognitive and perceptual attitudes—with regard to typeface design, the most popular of these measures being legibility (see Tinker, 1963; Burt, 1959). Other examples of measure include readability (see Zachrisson, 1965), reading rate (see Hughes & Wilkins, 2000), rate of fatigue, reading comprehension (see Archer & Elley, 1993), reading accuracy (see De Lange et al. 1993), miscue (see Reynolds et al., 2006), eye movements (see Buswell, 1922), distance (see Hughes & Wilkins, 2002), and letterform differentiation (see Walker, 2005).

In the survey conducted—for this present dissertation—on literature and research about how or whether children differentiate between typefaces, three *dimensions of sensitivity* were identified. These three dimensions of sensitivity—*performance*, *comprehension* and *preference*—represent the processes that were engaged in by subjects participating in the surveyed literature about how or whether children are sensitive to typeface design.

Performance As a dimension of sensitivity in this dissertation, performance refers to measures of performance identified in the surveyed literature and research about how or whether children differentiate between typefaces. Included in the performance dimension of sensitivity are the following measures: oral reading rate,

silent reading, rate of fatigue, visual acuity, visual stress, eye movements, readability and scanning.

Comprehension In this dissertation, the dimension of sensitivity; comprehension includes measures such as accuracy test, differentiability, legibility, miscue and recognition.

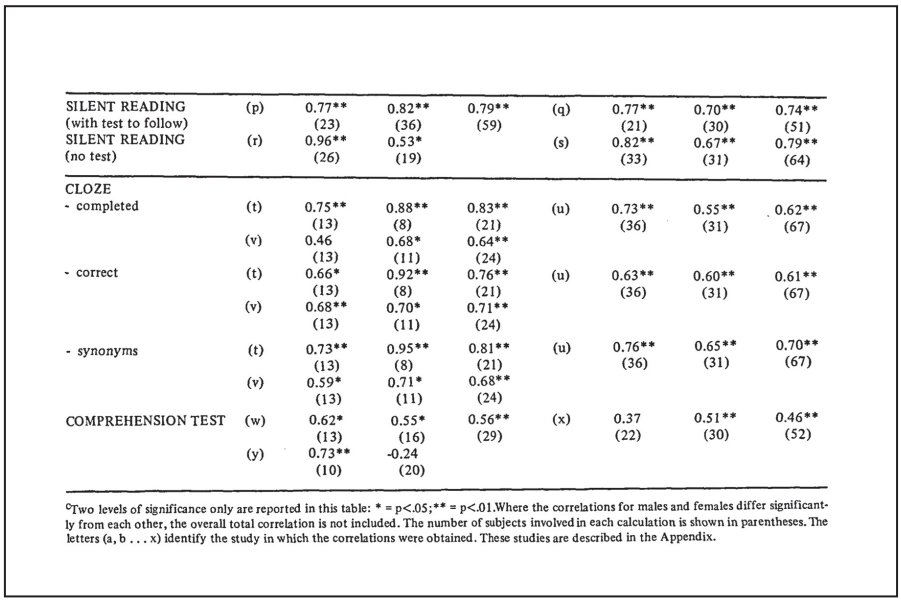
Preference Having the status of a dimension of sensitivity in this dissertation, preference refers to subjective measures of likes and/or dislikes.

It is thought important to note that the continued use of some of these measures throughout the years has not made these various measures of typographic research increasingly reliable. As a matter of fact, it must be noted that Hartley, Fraser and Burnhill (1975) remarked that oral measures have little worth in typographic research, and that even though some measures may be reliable they seem to lack sensitivity (see Figure 2.2 & 2.3). Hartley et al. (1975), based on their findings, propose that as a result of the complexity of typographic research more reliable measures must be found.

Table 1
The Reliability of Different Measures Used in Reading and Typographic Research[c]

Measures		*Reliability Coefficients*					
		University Students				School Students	
		Males	Females	Totals		Males	Females	Totals
READING ALOUD	(a)	0.72** (13)	0.97** (7)	0.78** (20)	(b)	0.91** (16)	0.94** (19)	0.92** (35)
					(c)	0.92** (16)	0.96** (19)	0.95** (35)
					(d)	0.95** (16)	0.92** (19)	0.92** (35)
					(e)	0.99* (13)	0.98** (22)	0.97** (35)
READING ALOUD (text upside down)	(f)	0.99** (14)	0.99** (7)	0.99** (21)	(g)	0.97* (4)	0.87** (12)	0.88** (16)
SCANNING: Technical material	(h)	0.86** (26)	0.91** (19)	0.88** (45)	(i)	0.81** (29)	0.75** (33)	0.75** (62)
SCANNING: Prose materials (short intervals)	(j)	0.55* (13)	0.63 (5)	0.49* (18)	(k)	0.68** (29)	0.61** (34)	0.64** (63)
			0.53 (16)					
SCANNING: Prose materials (wide intervals)	(m)	0.51 (9)	0.17 (7)	0.36 (16)	(n)	0.39* (28)	0.51* (33)	0.47** (61)
	(o)		0.83** (16)					

Figure 2.2
Showing reliability of reading aloud and scanning as measures used in typographic research. (Hartley, Fraser & Burnhill 1975)



SILENT READING (with test to follow)	(p)	0.77** (23)	0.82** (36)	0.79** (59)	(q)	0.77** (21)	0.70** (30)	0.74** (51)
SILENT READING (no test)	(r)	0.96** (26)	0.53* (19)		(s)	0.82** (33)	0.67** (31)	0.79** (64)
CLOZE								
- completed	(t)	0.75** (13)	0.88** (8)	0.83** (21)	(u)	0.73** (36)	0.55** (31)	0.62** (67)
	(v)	0.46 (13)	0.68* (11)	0.64** (24)				
- correct	(t)	0.66* (13)	0.92** (8)	0.76** (21)	(u)	0.63** (36)	0.60** (31)	0.61** (67)
	(v)	0.68** (13)	0.70* (11)	0.71** (24)				
- synonyms	(t)	0.73** (13)	0.95** (8)	0.81** (21)	(u)	0.76** (36)	0.65** (31)	0.70** (67)
	(v)	0.59* (13)	0.71* (11)	0.68** (24)				
COMPREHENSION TEST	(w)	0.62* (13)	0.55* (16)	0.56** (29)	(x)	0.37 (22)	0.51** (30)	0.46** (52)
	(y)	0.73** (10)	-0.24 (20)					

[a]Two levels of significance only are reported in this table: * = p<.05;** = p<.01.Where the correlations for males and females differ significantly from each other, the overall total correlation is not included. The number of subjects involved in each calculation is shown in parentheses. The letters (a, b . . . x) identify the study in which the correlations were obtained. These studies are described in the Appendix.

Figure 2.3 Showing reliability of silent reading and comprehension as measures used in typographic research. (Hartley, Fraser & Burnhill 1975)

Potential moderator variables

Meta-analysis is not solely a device for summarizing findings across a specific research field, but it is also a method for hypothesis testing. Researchers have measured and manipulated several factors that influence the cognitive and perceptual attitudes of children. In this dissertation meta-analysis will also allow for the investigation of the influence and impact of any potential moderators. The potential moderators identified in the literature and research about how or whether children differentiate between typefaces include *typographic factors, personal characteristics,* and *environmental factors.*

Typographic factors With regards to reading, researchers have investigated several factors that may bear influence on children's cognitive and perceptive attitudes (Betts, 1949; Zachrisson, 1965). Some of the most researched factors have been typographic in nature. Due of the complexity of typographic research, despite the fact that typographic factors were used as independent variables in the research literature analysed, it was hypothesised that typographic factors could also act as potential moderators. Considering typographic factors, three

main areas can be identified; these are type, spacing and layout (McCarthy & Mothersbaugh, 2002; Zachrisson, 1965; Betts, 1949).

Type includes size, face (serif, sans serif), style, weight, capitals, and lower case. Spacing includes line spacing (also referred to in the research literature as leading, inter-line space linefeed or line spacing), words spacing, letter spacing. Layout includes, line length, colour, justified composition, unjustified composition, margins, paragraph indention.

Personal characteristics On surveying the research literature it was observed that age and sex have been present in most of the investigations on whether children differentiate between typefaces. However, it seems that researchers did not take into account the possible impact of these factors. In this dissertation it was hypothesised that personal characteristics—age, sex, cognitive skills, physiological peculiarities, and psychological peculiarities—are potential moderators. Similarly, Hartley et al. (1975) remarks concern that few researchers considered the importance of sex differences.

Environmental factors Potential moderator variables identified in the survey of research literature in terms of environmental factors are distance from material, lighting, interface (paper surface), angle, 'real life', and familiarity (Watts & Nisbet, 1974).

3 Analysis of research data

3.1 Meta-analysis procedures

Meta-analysis was conducted following the methods outlined by Hunter et al. (1982) and Hunter & Schmidt (1990). The search process for research literature from 1911 until 2010 about how or whether children differentiate between typefaces yielded 45 articles (see Appendix A). The only restrictions placed on the inclusion of studies were that they must have measured and analysed children's sensitivity with regard to typeface design and that they were conducted between 1911–2010, inclusive.

After the relevant studies were selected (see Table 1 in Section 2.1 of this dissertation) from the 45 identified (see Appendix A), and critically analysed, the next step was to find out what empirical relationships have been revealed in the research literature about how or whether children are sensitive to typeface design, so that they may be taken into consideration for the construction of a theory of the relationship between and children's sensitivity and typeface design. In order to understand these relationships better, a table (see Table 2) summarizing the findings of these studies was complied. The visual image of this table is a representation of the complexity of typographic research.

In addition to the observed dimensions of sensitivity and potential moderator variables identified earlier in Section 2.2, sample sizes, correlations, year of study, sex, age, location and research design was recorded (see Table 2). It is hypothesised that age and gender of children might affect the extent to which they are sensitivity to typeface design. The year of study was included in the table, as it seemed that this data could reveal trends or patterns in these studies selected for analysis.

Table 2: Summary of study characteristics included in the meta-analysis.

				Personal characteristics			Typographic factors (independent variables and also potential moderators)																Environmental factors				Dependent variables				
				Sex		Grade/Year[1]	Type							Spacing			Layout														
Study	N	*r*	Year	Boys	Girls	Age	Type size in pts.	Type size in mm.	Typeface	Serif	Sans Serif	Infant characters	Lower case	Upper case	Line spacing	Word Spacing	Letter spacing	Line length	Justified layout	Unjustified layout	Colour	Paragraph indentation	Margins	Distance	Real life	Lighting	Familiarity	Performance	Comprehension	Preference	Country	Research design
1a	24	***0.61	2009	10	14	7–8	1!$^{+}$	1!$^{+}$	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1^{+}	1	0	UK	Exp
1b	32	*0.39	2009	18	29	8–10!	1!$^{+}$	1!$^{+}$	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1^{+}	0	UK	Exp
1c	80	**0.33	2009	38	42	8–9	1	1	1!$^{+}$	0	1!	1!	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	1	1^{+}	1	UK	Exp & Sur
1d	41	**0.39	2009	21	22	8–9	0	0	1!$^{+}$	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1^{+}	1	0	UK	Exp
2	24	?	2006	13	11	5–7	1	1	1	1	0	1	0	0	1!$^{+}$	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1^{+}	UK	Exp & Sur
3a	24	?	2004	10	14	5–7	1	0	1	1	0	1	0	0	1	1!	1	0	0	0	0	0	0	0	1	0	1	1	1	1	UK	Exp
3b	24	?	2004	11	13	5–7	1	0	1	1	0	1	0	0	1	1	1!$^{+}$	0	0	0	0	0	0	0	1	0	1	1	1	1^{+}	UK	Exp
4	24	?	2003	-	-	5–7	1	1	1!	1!	1!$^{+}$	1!$^{+}$	0	0	1	1	0	0	0	1	0	0	0	0	1	0	1	1	1	1^{+}	UK	Exp & Sur
5	200	?	2002	-	-	6–11	1!	1!	0	0	1	0	0	0	1!$^{+}$	1	1!$^{+}$	0	0	0	0	0	0	1	0	0	0	1^{+}	1^{+}	1^{+}	UK	WS &Sur
6a	80	?	2001	-	-	5–10!	1	0	1!	1!	1!$^{+}$	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1^{+}	0	USA	MD
6b	80	?	2001	-	-	5–10!	1!$^{+}$	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1^{+}	0	USA	MD
7a	56	?	2000	-	-	5–7!$^{+}$	1!$^{+}$	1!$^{+}$	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1^{+}	1^{+}	0	UK	Exp
7b	64	?	2000	-	-	8–11	1!$^{+}$	1!$^{+}$	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1	1^{+}	0	UK	Exp
8	16	?	1994	16	-	9-10!$^{+}$	0	0	1!$^{+}$	1!	1!	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1^{+}	0	0	USA	Exp
9	132	?	1993	62	70	8–9	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	UK	Exp
10	450	?	1993	-	-	-	1	1	1!	1!	1!	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	South Africa	Cor
11a	50 (SpcN)	?	1993	-	-	8–13	1!	0	1!	1!	1!$^{+}$	1!	0	0	1!$^{+}$	1!$^{+}$	0	0	1!	1!	0	0	0	0	0	0	0	0	0	0	1^{+}	UK	Sur
11b	50	?	1993	-	-	8	1!	0	1!	1!	1!$^{+}$	1!	0	0	1!	1!	0	0	1!	1!	0	0	0	0	0	0	0	0	0	0	1^{+}	UK	Sur
12	90	***0.67	1991	69	21	6–11	1!$^{+}$	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1^{+}	0	UK	Exp
13	137	?	1982	55	85	5–8	0	0	1	1	0	0	0	0	0	0	0	1!$^{+}$	0	1	0	0	0	0	0	0	0	1	1^{+}	0	UK	Exp
14a	145	?	1982	!$^{+}$	!	8–9!$^{+}$	1!$^{+}$	0	1!$^{+}$	1!	1!$^{+}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1^{+}	USA	Sur
14b	145	?	1982	!$^{+}$	!	11–12!	1!$^{+}$	0	1!$^{+}$	1!	1!$^{+}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1^{+}	USA	Sur
15	38	?	1980	-	-	5	1	0	1!	1!	1!	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	UK	Exp & Sur
16	31	?	1971	16	15	5–6	0	0	1!	0	0	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	UK	Exp
17	215	?	1971	-	-	4–9	0	0	1!	0	0	0	1!	1!$^{+}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1^{+}	0	UK	Exp
24a	72	?	1956	72	0	7–8	1!	1!	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	Sweden	Exp
24b	72	?	1956	72	0	10–11	1!	1!	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	Sweden	Exp
24c	72	?	1956	72	0	7–8	1!$^{+}$	1!$^{+}$	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1^{+}	Sweden	Sur
24d	72	?	1956	72	0	10–11	1!$^{+}$	1!$^{+}$	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1^{+}	Sweden	Sur
24e	72	**0.33	1954	72	0	7–8	0	1^{+}	1!$^{+}$	1!$^{+}$	1!$^{+}$	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1^{+}	0	Sweden	Exp
24f	48	0.14	1954	24	24	10–11	0	1!	1!	1!	1!	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0	Sweden	Exp
24g	24	0.05	1954	24	0	7–8	1	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	Sweden	Exp
24h	12	0.07	1954	6	6	10–11	1	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	Sweden	Exp
24i	24	0.42	1954	24	0	7–8	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	Sweden	Exp
24j	12	0.26	1954	6	6	10–11	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	Sweden	Exp
24k	24	?	1954	24	0	7–8	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	Sweden	Exp
24l	12	?	1954	6	6	10–11	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	Sweden	Exp
24m	72	?	1954	72	0	7–8	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Sweden	Sur
24o	48	?	1954	24	24	10–11	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	Sweden	Sur
25a	100	?	1927	-	-	8–10	1!	1!	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25b	50	?	1927	-	-	7–8	1!$^{+}$	1!$^{+}$	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1^{+}	1^{+}	0	USA	Exp
25c	40	?	1927	-	-	6–7	1!	1!	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25d	96	?	1927	-	-	8–10	1	1	0	0	0	0	0	0	1	0	0	1!	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25e	48	?	1927	-	-	7–8	1	1	0	0	0	0	0	0	1	0	0	1!$^{+}$	0	0	0	0	1	0	0	1	0	1	1^{+}	0	USA	Exp
25f	72	?	1927	-	-	6–7	1	1	0	0	0	0	0	0	1	0	0	1!	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25g	96	?	1927	-	-	8–10	1	1	0	0	0	0	0	0	1!	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25h	48	?	1927	-	-	7–8	1	1	0	0	0	0	0	0	1!$^{+}$	0	0	1	0	0	0	0	1	0	0	1	0	1	1^{+}	0	USA	Exp
25i	72	?	1927	-	-	6–7	1	1	0	0	0	0	0	0	1!	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	USA	Exp
25j	36	?	1927	-	-	6–7	1	1	0	0	0	0	0	0	1	0	0	1	1!	1!	0	0	1!	0	0	1	0	1	1	0	USA	Exp
26a	19	?	1923	-	-	8–9	1!	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	USA	Exp
26b	24	?	1923	-	-	9–10	1!	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	USA	Exp
26c	6	?	1923	-	-	9–11	1!	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	USA	Exp

[1] See Appendix D

SpcN = Special need children, Exp = Experiment, Cor = Correlated design, Sur =Survey, WS = Within-subjects, MD = Mixed design

1 = included in study, 0 = not included in study, ! = IV measured, ? = effect size could not be calculated, + = correlation

*p ≤ .05, **p ≤ .01, *** *p* ≤ .001

Effect sizes

Before conducting the analysis on the data collected from the selected studies (see Table 1)—following the methods outlined by Hunter et al. (1982) and Hunter & Schmidt (1990)—the statistical results collected—*t*-test values and *F* test values—were converted into effect size correlations once *t* and *F* values had one degree of freedom (see Appendix B for transformation formulas). The correlation measure of effect size *r* is the correlation between the independent variable classification and the individual scores of the dependent variable and eliminates the problem of sample sizes allowing a meaningful and easily interpretable value for comparison across studies (Hunter & Schmidt, 1990). This allowed for the examination of the impact of the various independent variables; type (e.g. size, face, serif), spacing (e.g. words spacing, line spacing), layout and so forth on the dimensions of sensitivity.

An example of this transformation of statistical results is the research of Wilkins et al. (2009). This study reported a *t-statistic* for speed of comprehension between a 26 pt. typeface (x-height = 5.0mm) and a 22 pt. typeface (x-height = 4.2mm); the transformed correlation in this instance represents a relationship between comprehension and type (in particular type size). All the studies in Table 2 do not have the effect size correlation value *r*, this is either because no data was available to calculate the transformation or if there was data available the research design did not permit for the effect size correlation value to be calculated (see Table 2).

Table 3: Correlations between typeface and comprehension

				Personal characteristics			Typographic factors (independent variables and also potential moderators)																Environmental factors				Dependent variables				
				Sex		Grade/Year[1]	Type								Spacing			Layout														
Study	N	*r*	Year	Boys	Girls	Age	Type size in pts.	Type size in mm.	Typeface	Serif	Sans Serif	Infant characters	Lower case	Upper case	Line spacing	Word Spacing	Letter spacing	Line length	Justified layout	Unjustified layout	Colour	Paragraph indentation	Margins	Distance	Real life	Lighting	Familiarity	Performance	Comprehension	Preference	Country	Research design
1c	80	**0.33	2009	38	42	8–9	1	1	1![!]$^{+}$	0	1!	1!	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	1^{+}	1	UK	Exp & Sur
24e	72	**0.33	1954	72	0	7–8	0	1^{+}	1![!]$^{+}$	1![!]$^{+}$	1![!]$^{+}$	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1^{+}	0	Sweden	Exp
24f	48	0.14	1954	24	24	10–11	0	1!	1!	1!	1!	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0	Sweden	Exp
24g	24	0.05	1954	24	0	7–8	1	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	Sweden	Exp
24h	12	0.07	1954	6	6	10–11	1	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	Sweden	Exp
24i	24	0.42	1954	24	0	7–8	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	Sweden	Exp
24j	12	0.26	1954	6	6	10–11	0	0	1!	1!	1!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	Sweden	Exp

[1] See Appendix D

Exp = Experiment, Sur =Survey

1 = included in study, 0 = not included in study, ! = IV measured, + = significant correlation

*p ≤ .05, **p ≤ .01, *** *p* ≤ .001

Analysis

One meta-analysis was conducted including seven of the studies (see Table 3) from the eleven studies for which effect size correlations could be calculated. Adhering to the methods outlined by Hunter et al. (1982) and Hunter & Schmidt (1990) each study was represented with one correlation per measured relationship. As there are three dimensions of sensitivity—as defined in Section 2.2 of this dissertation—this means that three separate relationships can be measured. However, since the goal here is to determine how or whether children are sensitive to typeface design, the meta-analysis conducted was on the correlations between typeface and the dimension of sensitivity: comprehension. The correlation between typeface and the dimensions of sensitivity: performance and preference did not include sufficient studies for which the effect size could be calculated; therefore these were not included. Hence, only one formal meta-analysis could be conducted to determine how or whether children are sensitive to typeface design.

Conducting the meta-analysis involved three steps; (1) the population correlation was calculated as a weighted average as this is considered best practice by Hunter et al. (1982) and Hunter & Schmidt (1990); then (2) the corresponding variance—population correlation variance—across studies was calculated, which in this case is the frequency weighted average squared error; next, (3) the variance population correlation across the seven studies was corrected for sampling error, this was done by subtracting sampling error variance from the frequency weighted average square error. (See Appendix B for meta-analysis formulas and Appendix C for calculations.)

As required information such as means and standard deviations was not reported in sufficient studies, apart from sampling error, other study artefacts were not corrected for. Consequently, variations in results are inevitable. Hunter et al. (1982) and Hunter & Schmidt (1990) suggest that if the residual variance across studies is greater than

25%, then the likelihood of the presence of a moderator relationship is significant and moderator analyses should be conducted to determine the source of the variance.

Meta-analysis results

Comprehension

The meta-analysis conducted (see results below in Table 4) indicates that the relationship between typeface design and comprehension has an average correlation of 0.27 and variance across studies was due to sampling error, signifying there were no moderator variables present (see Appendix C for meta-analysis calculations). These results indicate that children are moderately sensitive to typeface design via the dimension of comprehension. However, two studies out of the seven used to conduct the meta-analysis found a significant correlation between typeface design and comprehension while five found no correlation at all (see Table 3).

Table 4: Results of analysis of the seven studies

Relationship investigated	$\overline{r}$	#C	#SC	σ_r^2	σ_e^2	σ_ρ^2	σ_ρ
Typeface with Comprehension	0.265	7	2	0.012132	0.0222	-0.0101	0

#C = Number of Correlations #SC = Number of significant correlations

3.2 Quantitative analyses procedures

In this case a formal metal-analysis allowed only for the relationship between typeface design and comprehension to be measured. However, the data collected across the fifty-two studies contains information that has allowed for a further investigation (see Table 2). Procedures and results will be exposed in this section.

To gather further information as to how or whether children are sensitive to typeface design. Ten quantitative analyses were conducted. First, a quantitative comparison was prepared to show how many studies in the fifty-two included type, spacing and layout as typographic factors that can influence any of the three dimensions of sensitivity. Secondly, an analysis was made on how many studies actually measured type, spacing and layout as typographic factors. Next, three analyses were conducted to measure the effective relationships between the dimension of sensitivity and (1) type, (2) spacing and (3) layout. Following this, the frequency of each dimension of sensitivity was quantified across studies and compared to the frequency of affected dimensions of sensitivity.

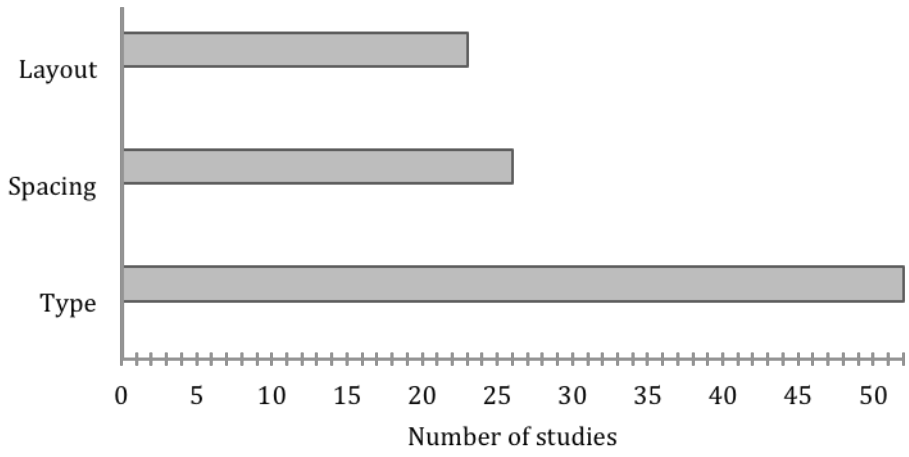
It was hypothesised that age may have an influence on how or whether children are sensitivity to typeface design. This hypothesis was investigated by first calculating the average age group across studies, then the relationship between age and the three dimensions of sensitivity was measured and compared.

The question this dissertation is trying to answer is how or whether children are sensitive to typeface design, hence, a quantitative analysis was conducted on the studies that measured typeface in relation to the three dimensions of sensitivity.

Results

The analysis of the fifty-two studies found that 100% of the studies included type as a typographic factor, 50% included spacing and 44% include layout (see Figure 3.1). However it was found that of the 100% that included type as a typographic factor, only 77% actually measured its effects on the dimensions of sensitivity. The studies, which measured spacing and layout were not significant (see Figure 3.2), of the fifty-two studies only 17% measured spacing and 13% measured layout as typographic factors that could possibly influence dimensions of sensitivity.

Figure 3.1: Frequency of Typographic factors included across the 52 studies.



With regards to the relationship between type as a typographic factor and the dimensions of sensitivity, it was found that 55% of the forty studies that measured type found it had an effect on the three dimensions of sensitivity (see Figure 3.3). However, this effect was not significant, 13% of these studies identified a relationship between type as a typographic factor and performance as a dimension of sensitivity; 18% identified a relationship between type and preference and 25% between type and comprehension.

Figure 3.2: Frequency of Typographic factors measured across the 52 studies.

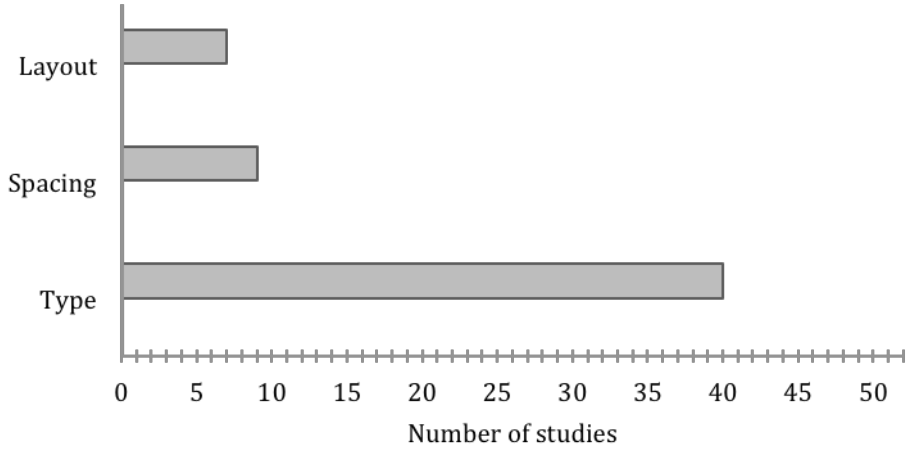
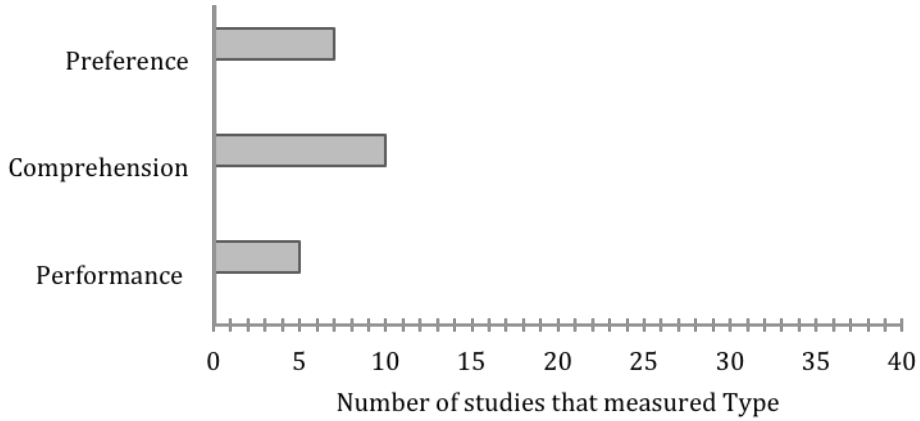
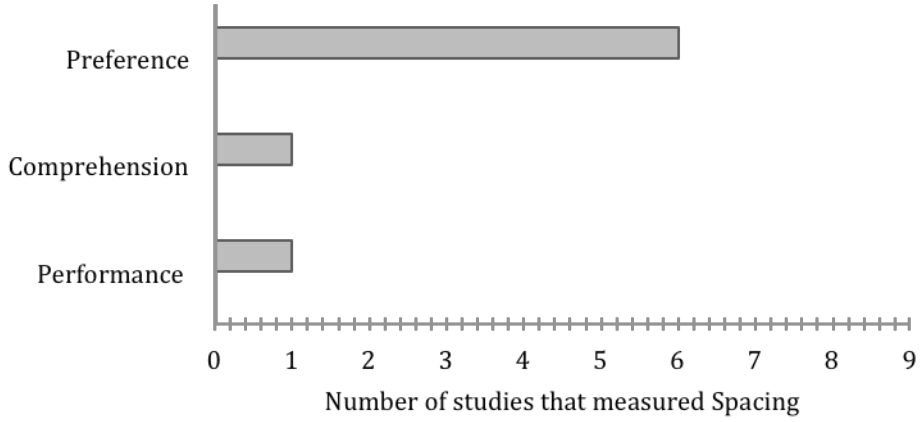


Figure 3.3: Relationship between Type and dimensions of sensitivity across the 40 studies that measured Type.



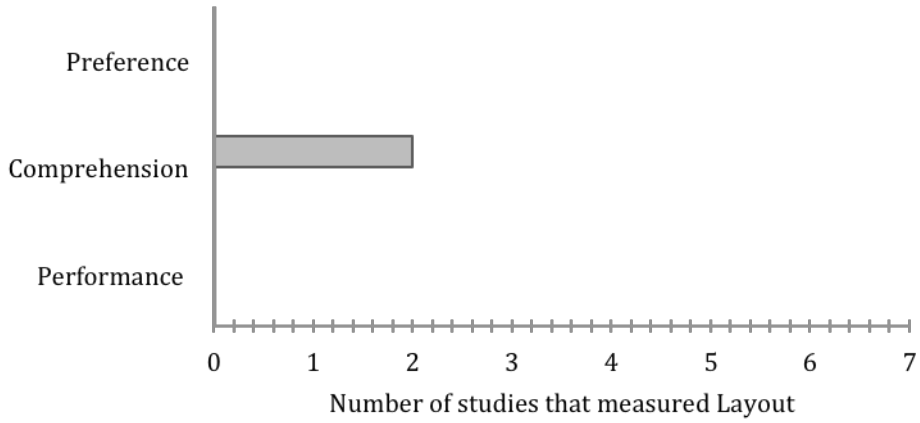
Concerning the relationship between spacing as a typographic factor and the three dimensions of sensitivity, it was found that of the nine studies that measured spacing, 89% found that spacing had an effect on the dimensions of sensitivity. The relationship between spacing and preference was significant (see Figure 3.4), 67% of the measured studies showed that spacing as a typographic factor had a moderate effect on the preference dimension of sensitivity. Performance and comprehension as dimensions of sensitivity each measured 11% on the nine studies.

Figure 3.4: Relationship between Spacing and dimensions of sensitivity across the 9 studies that measured Spacing.



Concerning the relationship between layout as a typographic factor and the dimensions of sensitivity, it was found that performance and preference as dimensions of sensitivity were not affected by layout as a typographic factor. However, 29% of the seven studies measured an effect between layout and comprehension (see Figure 3.5).

Figure 3.5: Relationship between Layout and dimensions of sensitivity across the 7 studies that measured Layout.



The quantitative analysis with regard to the frequency of the three dimensions of sensitivity showed that of the fifty-two studies 56% of the studies measured performance as a dimension of sensitivity, 77% measured comprehension and 27% preference (see Figure 3.6). Concerning the frequency of affected dimensions of sensitivity, 21% of the twenty-nine studies that measure preference as a dimension of sensitivity found that typographic factors had an effect on preference as a dimension of sensitivity, 35% of the forty studies that measured comprehension found that typographic factors had an effect on comprehension as a dimension of sensitivity, while 71% of the fourteen studies that measured preference found that typographic factors had an effect on preference as a dimension of sensitivity.(see Figure 3.7).

Figure 3.6: Frequency of dimensions of sensitivity measured across the 52 studies.

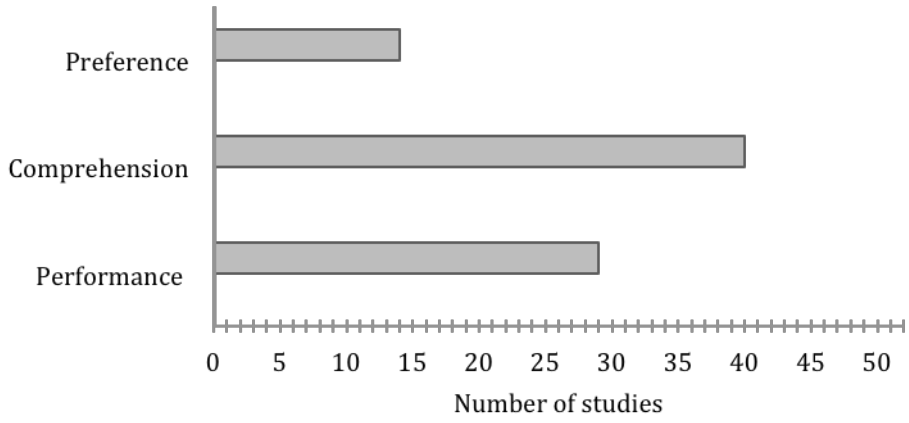
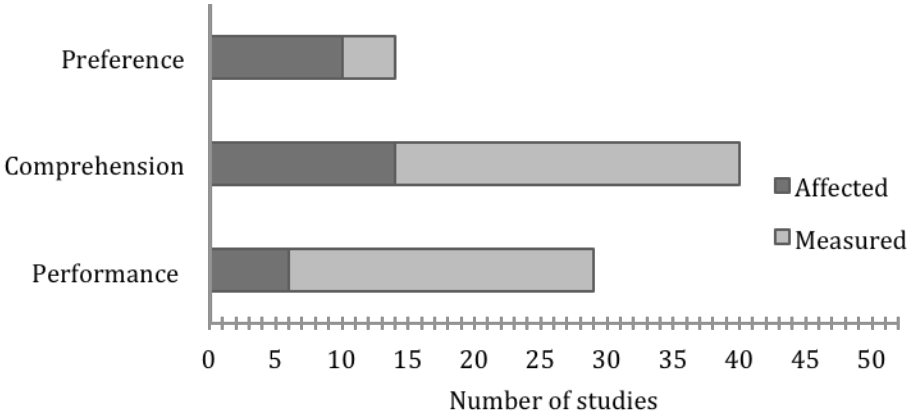
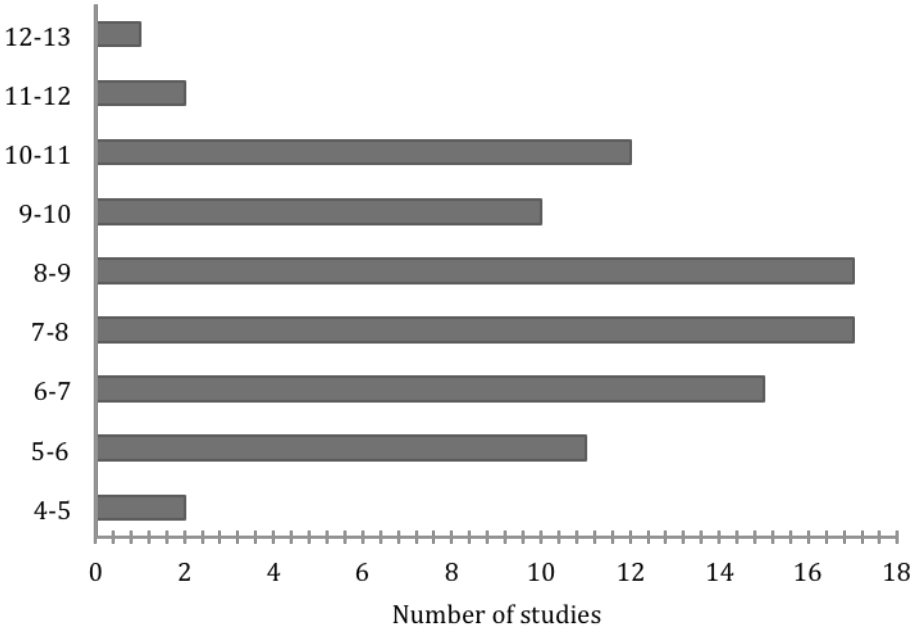


Figure 3.7: Frequency of affected dimensions of sensitivity across the 52 studies.



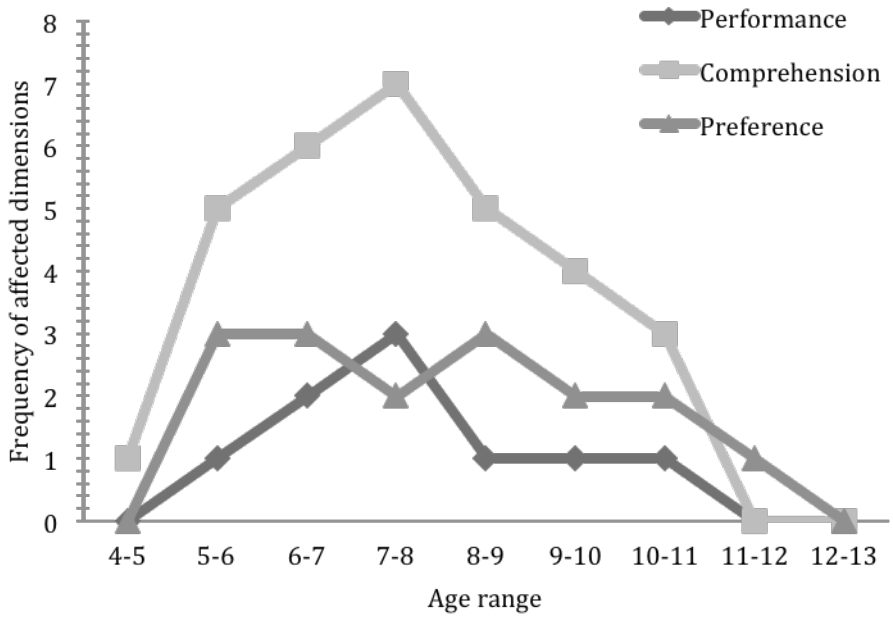
The mode age range across studies was found to be 7–9 with the 6–7 age group as the second most frequently investigated. The age group of 4–5 was very little investigated across the fifty-two studies surveyed (see Figure 3.8).

Figure 3.8: Mode age range across studies.



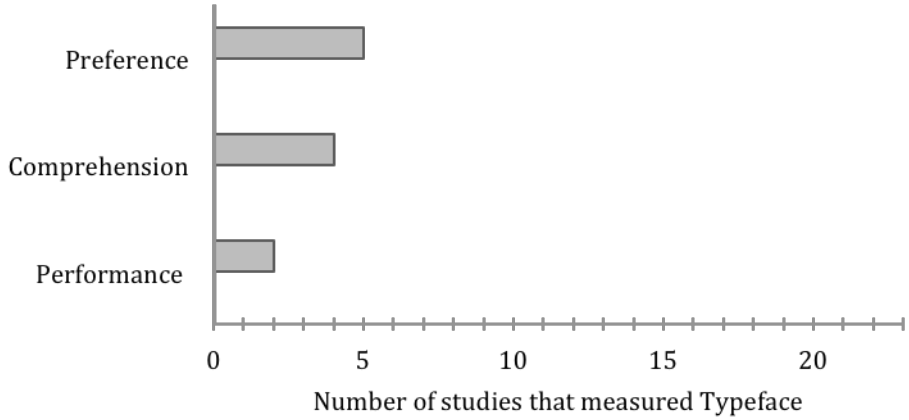
With regards to the relationship between age and the three dimensions of sensitivity, it was found that for children between 5–9 years of age, typographic factors significantly affected comprehension as a dimension of sensitivity. The analysis also showed that above 11 years of age, the effect of typographic factors on the three dimensions of sensitivity was not significant (see Figure 3.9).

Figure 3.9: Relationship between age and affected dimensions of sensitivity across studies.



It was found that the relationship between typeface and the three dimensions of sensitivity was not significant. Of the twenty-three studies that measure typeface 8.7% identified a relationship between typeface and performance as a dimension of sensitivity, 22% identified a relationship between typeface and preference, and 17% between typeface and comprehension (see Figure 3.10).

Figure 3.10: Relationship between Typeface and dimensions of sensitivity across the 23 studies that measured Typeface.



3.3 Discussion

To find out how or whether children are sensitive to typeface design formal (following the methods of Hunter et al., 1982; and Hunter & Schmidt, 1990) and informal (quantitative) meta-analyses were conducted across fifty-two studies that tested the sensitivity of children across three dimensions. The results demonstrate that typeface design influences the sensitivity dimensions of preference and comprehension more than it does performance. However, the results also demonstrate that more research is need in the areas of spacing and layout as typographic factors, as well as in the investigation of the role of age and sex with regards to the dimensions of sensitivity. The results of the formal meta-analysis did not allow for moderator analyses to be conducted and therefore the existence of moderator variables could not be confirmed from the formal meta-analysis.

The results from the formal meta-analysis demonstrate that children are moderately sensitive to typeface design via the dimension of sensitivity: comprehension. These results also suggested that no

moderator variables were present, however, two of the seven studies used to conduct the formal meta-analysis were significant, these are: Study 1c and Study 24e. Upon closer observation, it was noticed that Study 1c and Study 24e along with Study 24f differed from the other four studies in that line spacing was included in these three studies. However, the results of study 24f were not significant and this is perhaps because the age group of participants in this study was 10–11 which is the age group according to Tinker (1965) and Buswell (1922), which has already developed adult reading habits and therefore to some extent are less affected by typographic factors. Hence, it may be deduced that the presence of line spacing as a typographic variable could be responsible for Study 1c and Study 24e having significant results and therefore line spacing may be considered a moderator variable. Therefore, it may be that the combination of typeface and line spacing resulted in a significant effect on comprehension as dimension of sensitivity.

It was hypothesised that age may have an influence on how or whether children are sensitivity to typeface design. The results in Figure 3.9 demonstrate that this hypothesis is true. On all three dimensions of sensitivity—preference, performance and comprehension—a decrease in the frequency of affected dimensions was observed from the age 10–13. Whereas, from age 4–7 it was observed that the frequency of affected dimensions were increasing. These results appear to be consistent with the research of Tinker (1965) and Buswell (1922) who argue that children age 10 and above already have developed reading habits and are less affected by typographic factors than younger children.

The results also indicate that the age group that has a tendency to be more affected across the three dimensions of sensitivity, age 4–7, have been less investigated as compared with children ages 7–9. This could imply that current thinking with regards to children and

typography might not be applicable to this younger age group, as sufficient research has not been conducted on this population.

It was also observed that in all of the fifty-two studies coded (see Table 2) there were no significant difference found between serif and sans serif faces on the dimensions of sensitivity; performance and comprehension. These findings are consistent with the work of the Typographic Design for Children project based in the Department of Typography & Graphic Communication at the University of Reading. However, it was observed that children of all ages had a preference for sans serif faces, but this may be due to the interaction of other typographic factors—moderator variables—such as line spacing (Figure 3.4 shows that 67% of the studies that measured spacing had an moderate effect on the dimension of sensitivity preference), words spacing or type size, and not solely as a result of face.

This preference for the sans serif face is also consistent with the results of the work done by the Typographic Design for Children project. In addition, it is also in line with what teachers seemed to think is best for young readers according to the study surveys carried out by Coghill (1980) and Raban. But what are teachers saying today? Is this favouring of sans serif fonts observed 30 years ago still consistent with teachers thinking today? This question is yet to be answered.

It was also observed from the research investigated here in this dissertation relating to the discipline of psychology—Asso & Wyke (1971) for example—that cerebral mechanisms play an important role in the way that children might be sensitive to typeface. An ideal research investigation would be to combine knowledge from multiple disciplines—typography, psychology, and education—and define a common question to investigate on the subject of children and typography.

The analysis carried out in this dissertation remains only surface deep and there are many underlying factors which come into play when considering the effect of typeface design on the three dimensions of

sensitivity discussed; such as the influence of moderator variables that are certain to exist—as it is well know that typographic factors are constantly interacting with each other (Betts, 1949)—that have not been explored here due to the format of this present work.

Furthermore, this dissertation has dealt solely with type in print, it cannot be ignored that children today from a very young age are coming into contact with type on interfaces other than the traditional book, for example; iPads, computers and so forth. How is this impacting their motivation on reading from traditional materials? Should more research on children and typography be carried out on modern interfaces rather than on traditional reading interfaces? Is children's sensitivity to typeface design on digital interfaces similar or different to that found in traditional reading materials?

Conclusion

In early nineteenth century researchers were exclusively interested in the legibility of type. At the turn of the century, research interests expanded also to include the investigation of type forms (see Roethlein, 1912). Actors in the areas of education, the visually handicapped, highway safety, linguistics and psychology to name a few became interested in research on the investigation of type forms (see Wrolstad, 1969). Following this, the twenty-first century brought with it an interest for research investigating children and type (see Hughes & Wilkins, 2000; Reynolds & Walker, 2004).

However, today, in the case of children and typeface design even though there is a flourishing interest by researchers, much is still to be done on the part of type designers. Type designers should not leave it up to researchers from other disciplines to give direction on a subject matter that is fundamentally that of a type designer.

Every discipline has its own agenda. Psychologists for example have done an enormous amount of research with regard to legibility, type size, and so forth (see Tinker, 1965; Cohn, 1886). Nevertheless, their interest is in psychological phenomena. In fact, the pioneer Javal interests were not in the domain of type forms or typography but in the domain of physiology. The argument being put forth here is that the type designer should not act as aestheticians, but rather productively engage in developing research methodologies to specific research questions while at the same time cultivating interdisciplinary exchange.

In response to the question this dissertation set out to answer: Are children sensitive to typeface design? The results from the analysis of fifty-two coded studies (Table 2) show that children are moderately sensitive to typeface design relative to the three dimensions of sensitivity; performance, comprehension and preference, with preference being the most affected dimension. The results have also demonstrated that children aged 4–7 are the most sensitive to the three dimension of sensitivity; performance, comprehension and preference.

The implications for the type designer are that children know what they like or do not like to read therefore when designing type for children age 4–7 their preferences should be taken into consideration as motivation has a key function for beginner readers.

It is hoped that in the near future, there will be an opportunity to carry out a more in-depth analysis across studies bringing together research from multiple domains regarding the question of children and their sensitivity to typographic factors.

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Appendices

Appendix A

List of studies identified

1. **2009.** *Typography for children may be inappropriately designed.* Arnold Wilkins, Roanna Cleave, Nocola Grayson and Louise Wilson.
2. **2006.** *Children's responses to line spacing in early reading books or "Holes to tell which line you're on".* Linda Reynolds, Sue Walker, and Alison Duncan.
3. **2005.** *The songs the letters sing: typography and children's reading.* Sue Walker; arose from the Typographic Design for Children project.
4. **2004.** *'You can't see what the words say': word spacing and letter spacing in children's reading books.* Linda Reynolds and Sue Walker.
5. **2003.** *Serifs, sans serifs and infant characters in children's reading books.* Sue Walker and Linda Reynolds.
6. **2002.** *Reading at a distance: Implications for the design of text in children's big books.* Laura E. Hughes and Arnold J. Wilkins.
7. **2001.** *Effects of typeface and font size on legibility for children.* Rebecca J. Woods, Kristi Davis and Lauren F. V. Scharff.
8. **2000.** *Typography in children's reading schemes may be suboptimal: Evidence from measures of reading rate.* Laura E. Hughes and Arnold J. Wilkins.
9. **1994.** *The effect of print size on reading rate for adults and children.* Jan E. LouieKitchin, Nelson J. Oliver, Adrian Bruce, Michelle S. Leighton, and Wendy K. Leigiaton.
10. **1994.** *Effects of typeface characteristics on visual fields asymmetries for letter identification in children and adults.* Nancy M. Wagner and Lauren Julius Harris.
11. **1994.** *An investigation into the effects of word spacing on the fluency and accuracy of novice readers.* G. Cooper-Tomkins

12. **1993.** *Do print size and line length affect children's reading comprehension.* Averill J. Archer and Warwick B. Elley.
13. **1993.** *Performance differences between Times and Helvetica in a reading task.* Rudi W. De Lange, Hendry L. Esterhuizen and Derek Beatty.
14. **1993.** *Through the eyes of a child — Perception and type design.* Rosemary Sassoon.
15. **1993.** *The effect of print size on achievement in Mathematics problem solving.* William H. Nibbelink, Jean A. Gerig, Hiram D. Hoover.
16. **1991.** *What children see affects how they read.* Piers Cornelissen, Lynette Bradley, Sue Fowler, John Stein.
17. **1988.** *The Design of Print for children: sales-appeal and user-appeal.* Valerie Yule.
18. **1982.** *Text display effects on the fluency of young readers.* Bridie Raban.
19. **1982.** *Children's preferences for format factors in books.* Maria J. Weiss.
20. **1980.** *Can children read familiar words set in unfamiliar type?* Vera Coghill.
21. **1971.** *Discrimination of spatially confusable letters by young children.* Doreen Asso and Maria Wyke.
22. **1971.** *Why do children reverse letters?* Uta Frith.
23. **1971.** *Children's perception of differently oriented shapes: Word recognition.* Ruth F. Deich.
24. **1971.** *Simultaneous and successive discrimination of similar letters.* Joanna P. Williams and Margaret D. Ackerman.
25. **1970.** *Cues to word similarity used by children and adults: Supplementary report.* Virginia Lee Fisher and Jill H. Price.
26. **1970.** *Role of letter-position cues in learning to read words.* Calvin F. Nodine and James V. Hardt.
27. **1970.** *Cues used in visual word recognition.* Joanna P. Williams Ellen L. Blumberg and David V. Williams.
28. **1969.** *Visual-motor skills: Response chracteristics and pre-reading behaviour.* Katherine P. DiMeo.
29. **1965.** *Cues by which children recognize words.* Gabrielle Marchbanks and Harry Levin.
30. **1956.** *Experiments in the Reading of running text and isolated words— Experiment 11 (Oral reading).* Bror Zachrisson.
31. **1956.** *Experiments in the Reading of running text and isolated words— Experiment 12 (Silent reading).* Bror Zachrisson.

32. **1956.** *Experiments in the Reading of running text and isolated words—Experiment 13 (Reader's opinion).* Bror Zachrisson.
33. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 4 (Oral reading).* Bror Zachrisson.
34. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 5 (Silent reading).* Bror Zachrisson.
35. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 6 (Tachistoscope).* Bror Zachrisson.
36. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 7 (Focal variator).* Bror Zachrisson.
37. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 8 (Perimeter).* Bror Zachrisson.
38. **1954.** *Experiments in the Reading of running text and isolated words—Experiment 10 (Reader's opinion).* Bror Zachrisson.
39. **1963.** *Legibility of print for children in upper grades.* Walter J. McNamara, D.G. Paterson, and Miles A. Tinker.
40. **1953.** *The influences of size of type on speed of reading in primary grades.* Miles A. Tinker.
41. **1931.** *New data on the typography of textbooks.* B. R. Buckingham
42. **1927.** *Investigations in the hygiene of reading.* J. H. Blackhurst.
43. **1923.** *The effect on reading of changes in size of type.* A. R. Gilliland.
44. **1923.** *Length of line as related to the reading ability in the first four grades.* J. H. Blackhurst.
45. **1922.** *Size of type as related to the reading ability in the first four grades.* J. H. Blackhurst.

*Studies in grey were not consulted first hand.

Numbers in this list do not relate to Study #.

Appendix B

Transformation formulas for converting test statistics

Studies using the *t* statistic:

$r = t/\sqrt{t^2 + df}$

$d = 2t/\sqrt{df}$

Studies using the *F* statistic:

$r = \sqrt{F}/\sqrt{F + df_{Error}}$

$d = \sqrt[2]{F}/\sqrt{df_{Error}}$

Meta-analysis formulas

Estimated population correlation:

$$\overline{r} = \frac{\Sigma[Nr]}{\Sigma \mathrm{N}}$$

Variance across studies (frequency weighted average squared error):

$$\sigma_r^2 = \frac{\Sigma[N(r - \overline{r})^2]}{\Sigma \mathrm{N}}$$

Sampling error variance:

$$\sigma_e^2 = \frac{\left(1 - \overline{r}^2\right)^2 K}{\mathrm{N}}$$

K is the number of studies in N.

Variance of population correlation:

$\sigma_\rho^2 = \sigma_r^2 - \sigma_e^2$

Appendix C

Meta-analysis calculations

Comprehension:

$$\overline{r} = \frac{72.12}{272} = 0.265$$

$$\sigma_r^2 = \frac{3.12}{272} = 0.012$$

$$\sigma_e^2 = \frac{6.050}{452729} = 0.022$$

$$\sigma_\rho^2 = 0.012 - 0.022 = -0.0100$$

$$\sigma_\rho = 0$$

Appendix D

School ages in England and the United States of America

England	
Foundation stage 1	Nursery: age 3 to 4
Foundation stage 2	Reception: age 4 to 5
Key stage 1	Year 1: age 5 to 6
	Year 2: age 6 to 7
Key stage 2	Year 3: age 7 to 8
	Year 4: age 8 to 9
	Year 5: age 9 to 10
	Year 6: age 10 to 11

United States of America	
Preschool	Pre-kindergarten: age 4 to 5
Elementary school	Kindergarten: age 5 to 6
	1st Grade: age 6 to 7
	2nd Grade: age 7 to 8
	3rd Grade age 8 to 9
	4th Grade age 9 to 10
	5th Grade age 10 to 11
Middle school	6th Grade age 11 to 12
	7th Grade age 12 to 13
	8th Grade age 13 to 14