

Accessible Font

A typeface for teaching strategies of autistic individuals based on latin script

Master Thesis

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Summary

The present research is based on studies in the areas of psychology, pedagogy and design. It was investigated the reading process and reading education strategies of individuals with autism spectrum disorders (ASD) with the purpose of developing a typographic system to assist pedagogues and to develop educational aids appropriate for child's reading problems. It was used interdisciplinary research methodology in this thesis with literature study, interviews with experts and a survey study. The survey was based on the opinions and experiences of special education teachers and the following findings were presented:

- The student with autism may have difficulties learning to read.
- They may mistake similar letters with each other, for example b and p, due to the similarity in letter shape.
- Their reading pattern may be characterized by impaired or normal delayed reading pattern.

According to the combined results of special education teachers' common opinions, legibility studies and literature study, the prototype of a typeface for individuals with autism, learning disabilities was developed. The Accessible Typeface v.1, v.2, v.3, v.4 v.5 family has been developed with the intention to ease individuals ability to learn reading and minimize mistakes in reading. However, before being implemented, this font family should be tested to conclude whether it is beneficial or not to teach an individual who has an autism or learning disabilities in reading.

Preface

This master's thesis is the result of thirteen months of work carried out in Portugal and Turkey. This thesis is made as a completion of the master education in Graphic Design. Yours truly has a bachelor degree in Dokuz Eylül University in art education and this thesis is the product of the master period, which is the last part of the: Escola Superior de Artes e Design de Caldas da Rainha, Polytechnic of Leiria, Graphic Design department.

Several people have contributed and supported this master thesis both academically and practically. The results of this research would not have been possible without the help of various people. I would therefore firstly like to thank my supervisors, Ricardo Santos and Aprigio Morgado for their time, valuable input and support throughout the entire master period. Furthermore, I would like to thank, Kudret Nurdağ, Dolunay Özentürk, Saniye Karagözoğlu Special Education School, Anadolu Autism Foundation and Lerzan Special Education Center for their big help throughout the autism education and survey process.

Finally I would like to thank my family and friends for being helpful and supportive during my time studying at Escola Superior de Artes e Design de Caldas da Rainha.

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Chapter 1

Introduction

1.1 Typography

Reading is unquestionably an important topic. Reading is a process that attracts the attention of many cognitive scientists, because many fundamental cognitive processes participate in the reading. In the reading process, the reader should recognize the printed words quickly and accurately, understand the meaning of the words, and create a mental model of the meaning of the text (Snow, 2002; Denton & Otaiba, 2011).

A typeface is a reading device. The research has shown that different typefaces can influence reading speed as much as 30% (Chauncey, 1986). Historically, publishers have believed that typefaces can increase or decrease the ability of the individuals to read (Tinker, 1963). The attributes of a typeface can influence the legibility to a great extent (Yager, Aquilante, & Plass, 1998). Readability or legibility can be assessed by examining the individual characteristics of a typeface or by examining the differences between the typefaces. Both approaches have limitations and will surely lead to different results. While teachers teach students to read, they think that some typeface are more useful in learning to read, but this view is based on teachers' prejudices (Bessemans, 2016). According to the Woods, Davis, & Scharff (2005), Arial (a sans-serif) is more legible than Times New Roman (a serif) for students in learning to read, and teachers support that evidence (Bessemans, 2016). In addition, it were found Comic Sans MS, Arial and Times New Roman typefaces, regardless of size, to be more readable (as measured by a reading efficiency score) than Courier New. In general, the 14-point size and the examined sans serif typefaces were perceived as being the easiest to read, fastest, most attractive, and most desirable for school-related material (Michael, Chaparro, Mills, & Charles G. Halcomb, 2002). Based on these evidence, we can understand how important the differences in typeface is for both reading and learning.

1.2 Autism

Autism is a severely disabling life-long developmental disability which typically appears during the first three years of life. No any known factors in the psychological environment of a child have been shown to cause autism (Woods, Davis, & Scharff, 2005). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), a guide created by the American Psychiatric Association used to diagnose mental disorders, people with ASD have:

- Difficulty with communication and interaction with other people.
- Restricted interests and repetitive behaviors.
- Symptoms that hurt the person's ability to function properly in school, work, and other areas of life.

Individuals with autism are known as good decoders, they have a reading comprehension problem which can be characterized with *hyperlexia*¹(Newman, et. al. 2007). For this reason, the literature is generally focused on the problem of reading comprehension of individuals with autism (Fernandes, de La Higuera Amato, Cardoso, Navas, & Molini-Avejonas, 2015). But interestingly, Nation (2006) stated that there is a poor word reading subgroup in the population of autism. But this subgroup has not been investigated much in previous researchs. However, Åsberg & Sandberg (2012) cited that the poor reading profile of autism does not match with a *dyslexic*² profile (Åsberg & Sandberg, 2012). In addition, studies conducted in the field of education reported that individuals with autism may have difficulties in learning to read (Laz, 2009). These contradictory results have led us to conduct our research and to investigate the problems faced by the nation's poor reader subgroup.

1.3 Research questions

Does it make sense to create a typeface to teach individuals with autism to read more easily?

What are the requirements of the individuals with autism in the reading process (which characters, words, and letterspacing)?

¹Hyperlexia is a syndrome characterized by an intense fascination with letters or numbers and an advanced reading ability. Hyperlexic children read at levels far beyond those of their age mates and often begin reading at very young ages, sometimes at age two (Center for Speech and Language Disorders).

²Dyslexia is a common learning difficulty that can cause problems with reading, writing and spelling. It's a specific learning difficulty, which means it causes problems with certain abilities used for learning, such as reading and writing (National Health Service, 2018).

What characteristics must the typeface have to help individuals with autism to read?

1.4 Aims

This research aims to investigate the requirements of individuals with autism in the process of learning to read and reading, according to these requirements design a typeface that covers their needs in the reading. For this purpose, it will be investigated some of the contradictory information found in the literature and designed a new typeface according to the investigation results, legibility studies and typeface design empiric knowledge. The research will try to fill the missing part of the literature and encourage future research.

This research aims to investigate the requirements of individuals with autism in the process of learning to read, reading and find out how to design a new typeface for them to read more easily. For this purpose, it will be investigated some of the contradictory information found in the literature and designed a new typeface according to the investigation results, legibility studies and typeface design empiric knowledge. The research will try to contribute the missing part of the literature and encourage future research.

1.5 Procedure

Our study occurs in two phases. The first phase follows a mixed non-interventional methodology. We use qualitative methods as bibliographic research, literature review, interview and survey methods, and quantitative methods for analyzing the results. From these, we establish the state of art in order to conceptually frame the second phase of the research. In this second phase, we follow a qualitative interventional methodology. We used qualitative methods such as exploratory drawing by hand, vector drawing, letter spacing and kerning in order to develop a font family.

Chapter 2

Framework

2.1 Autism Spectrum Disorders

Autism spectrum disorder (ASD) is a *developmental disability*³ defined by diagnostic criteria that affect basic human behaviors such as social interaction, ability to communicate ideas and emotions, imagination, the establishment of relationships with others that can persist throughout life (American Psychiatric Association, 2013). Autism spectrum disorder (ASD) occurs at birth or very early in development, and in many cases with mental retardation and language impairment. About 1 in 59 children has been identified with autism spectrum disorder (ASD) according to estimates from CDC's (Center for Disease Control and Prevention) Autism and Developmental Disabilities Monitoring (ADDM) Network (Baio, Wiggins, Christensen, & al., 2014).

Surveillance Year	Birth Year	Number of ADDM Sites Reporting	Prevalence per 1,000 Children (Range)	This is about 1 in X children...
2000	1992	6	6.7 (4.5-9.9)	1 in 150
2014	2006	11	16.8 (13.1-29.3)	1 in 59

Table 1 Identified Prevalence of Autism Spectrum Disorder ADDM Network 2000-2014 Combining Data

³Developmental disabilities are a group of conditions due to an impairment in physical, learning, language, or behavior areas. These conditions begin during the developmental period, may impact day-to-day functioning, and usually last throughout a person's lifetime (Pa & Febiger, 1989).

Autism spectrum disorders (ASD) and Autism are currently used to describe *three of the five pervasive developmental disorders*⁴. Three of the pervasive developmental disorders are Autism Disorder, Asperger Syndrome, and PDD-NOS. Autism Spectrum Disorder can occur with different symptoms in each individual with autism. For this reason, autism is known as a spectrum disorder which means there are a variety of similar features in different people with the same disorder. (American Psychiatric Association, 2000; Faras, Ateeqi, & Tidmarsh , 2010)

Despite being unique, individuals with autism spectrum have some common characteristics existing within the population. The characteristics vary in intensity, degree, amount and manifest differently from person to person and over time. These characteristics associated with autism were defined in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5™). Social communication impairments, speech language impairments, restricted repetitive and stereotyped patterns of behavior, interests and activities, executive function impairments, and common learning characteristics are common characteristics existing within the population of autism (Pratt, Hopf, & Larriba-Quest, 2017). Diagnosing ASD requires a comprehensive, systematic, and structured approach. There is no medical test that can diagnose ASD. Instead, specially trained physicians and psychologists administer autism-specific behavioral evaluations. Early diagnosis of autism is critical for individuals, because treatments are more effective in early age (18-24 months) (Guthrie, Swineford, Nottke, & Wetherby, 2012; Brentani, et al, 2013). Several studies have emphasized that the gains in functioning associated with early treatment will benefit children with ASD. As prevalence rates increase and diagnosis is made earlier, the demand for ASD treatments increases (Volkmar & Klin, 2005; Fombonne, 2005; Tidmarsh, 2003; Lord & Schopler, 1988). Intensive Behavioral Intervention (IBI) is the most effective treatment for autism, however, families who use behavioral treatments for autism commonly use other treatments as well (Goin-Kochel, Myers, & Mackintosh, 2007; Green, et. al., 2006). Helfin and Simpson presented 32 interventions believed to be in common use for treating children with autism in their report. The general literature review revealed some treatments had supporting evidence, while others were understudied or had evidence indicating that the treatment was ineffective or even potentially harmful (Heflin & Simpson, 1998).

⁴The diagnostic category of pervasive developmental disorders (PDD) refers to a group of disorders characterized by delays in the development of socialization and communication skills. The five pervasive developmental disorders are Autistic Disorder Asperger disorder, Rett disorder, Childhood disintegrative disorder, Pervasive developmental disorder- not otherwise specified (PDD-NOS).

2.1.1 Education of Individuals with Autism

The rate of children diagnosed with autism spectrum disorder increased by 78% between 2002 and 2008, (Centers for Disease Control and Prevention, 2012). This increase among children with ASD has affected the emergence of new research and training strategies. The education of children with autism disorders was accepted as a public responsibility under the Education of All Handicapped Children Act in 1975 in United States but, this law changed with the Individuals with Disabilities Education Act (IDEA) (P.L. 105-17) of 1997, becoming more inclusive (Public Law No. 94-142). A general framework for the rights of individuals with autism was presented at the 4th Autism-European Congress (Den Haag, 10 May 1992) and was adopted by the European Parliament as a Written Declaration (9 May 1996), those rights also include education of autism (right-3) ([European Commission Health & Consumer Protection Directorate, February 2005](#)). Those laws and rights have been implemented to develop new interventions and education strategies for people with autism. It is clear that autism needs the special education programs. Since 1971 many educational programs and strategies have been developed for individuals with ASD ([European Commission Health & Consumer Protection Directorate, February 2005](#)). There is no specific cure for ASD, however early intervention and education strategies are the treatment methods for children with ASD. The primary specially tailored educational strategies and treatment methods are; Association of Behavior Analysis (ABA), the structured teaching method in Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH), and Picture Exchange Communication System (PECS) ([National Research Council, 2001, s. 34-62](#)).

Autistic spectrum disorders have implications for development in ways that affect children's educational goals and appropriate strategies for teaching them. Also, language development, nonverbal communication, cognitive abilities and deficits in other areas are evident behaviors and outcomes with effects on the educational goals of children with autism spectrum disorder. However, it is not clear yet that specific educational objectives and strategies are associated with specific diagnoses in the spectrum of autism such as Asperger's Disorder, Childhood Disorder, or PDD-NOS. Education and treatment programs are generally aimed at improving social and academic skills of ASD. The most critical aspects in the design of educational programs for children with autism spectrum disorders concern the perception of the autism spectrum as a whole taking into account all the symptoms.

We need to perceive our work as a whole with all the symptoms of autism and do it accordingly. The Committee on Educational Interventions for Children with Autism recommends that children with any autism disorder (autism disorder, Asperger's disorder, atypical autism, PDD-NOS, childhood dysmorphic disorder) should be recommended regardless of their level of violence or functionality, so that they may benefit from special education services in the autism category (Suppo, Jennifer, & Michael, 2014; National Research Council, 2001). Children with autism spectrum disorders share unique obstacles with children with other developmental disorders, but present unique challenges for parents, teachers, and others working with them, especially in nonverbal and verbal communication and behavioral problems (National Research Council, 2001).

2.1.2 Patterns of Reading Ability in student with Autism Spectrum Disorder

Reading is a complex skill, and even reading a simple sentence requires a set of skills that can distinguish each word from the concept of the intended meaning of a text. Although reading is one of the most important skills learned in school (Perfetti, Landi, and Oakhill 2005; National Early Literacy Panel, 2008). The results of the current research show that the reading assessment and reading pattern of individuals with autism are independent and variable (Whalon & Barnett, 2010). IQ, age, and symptoms are factors that differentiate the needs of these groups from one another (Kelly J. Whalon, 2009). Studies prove that individuals with autism have hyperlexia reading profiles, but at the same time cannot extract information from within the text (reading comprehension) (Newman, et. al. 2007). Despite this, different researchers have proved that individuals with autism are poor at reading words and non-words and unable to decode non-words (Nation, 2006). Based on both, research shows that reading ability differs amongst children with ASD. Also, a literature study conducted by examining 58 articles showed that the reading and literacy ability of children with ASD varied from each other, (Fernandes, de La Higuera Amato, Cardoso, Navas, & Molini-Avejonas, 2015) also clearly struggle with reading (Arciuli, 2013).

Researchers tried to solve both of those significant problems of individuals with autism through computer-based programs and education strategies. The results show that using computer-based programs to help improve reading comprehension and literacy ability (Chiang & Lin, 2007; Whalon, Al Otaiba, & Delano, 2009; Ramdoss, 2011; Basil & Reyes, 2003). Also, computer-based programs (CBI) have provided better results than

the teachers who teach vocabulary to individuals with autism. In the study of grammar instruction with CBI on individuals with autism, students learned % 74 of the words through CBI, but this percentage dropped to 41% when done by teachers. The results show positive results according to the role of CBI use in teaching grammar on student with autism (Moore, 2000; Ramdoss, 2011). Those variable reading patterns of autism have provided different research fields for researchers, and at the same time proved that there is not one reading profile in autism (Nation, 2006). Studies indicate that interventions are limited, more interventions and research should be undertaken (Whalon, Al Otaiba, & Delano, 2009). The emerging knowledge shows that it is a significant mistake to have just one perspective when we are examining ASD, we have to examine with multiple perspectives to ASD for achieving the aim of the investigations otherwise it's impossible to achieve the aim of the investigation.

2.2 The Reading Process

Reading is unquestionably a big topic. Reading covers many processes from the definition of characters to the critical analysis and integration of large texts. Reading is a process that attracts the attention of many cognitive scientists because many fundamental cognitive processes are involved in reading. The reader should recognize the printed words quickly and accurately, understand the meaning of the words, and create a mental model of the meaning of the text (Snow, 2002; Denton & Otaiba, 2011). In the last twenty or thirty years there have emerged models designed to account for some specific aspect of the reading process.

"There are no models yet, that cover every aspect of the reading process. As an example, the models of word identification are often referred to as 'models of reading. There are models that account for: 1) Word identification, 2) Syntactic parsing, 3) Discourse representations, and 4) How certain aspects of language processing (e.g., word identification), in conjunction with other constraints (e.g., limited visual acuity, saccadic error) guide readers' eyes (Rayner & Reichle, 2010)".

As a simple review of the reading, the process covers two elements. According to Zimmerman (2003), these are external and internal. The external element of the reading is to the words. The internal element of reading is the comprehension of the text. The intrinsic reading element is the real understanding of the texts that enable the students to understand the text content.

2.2.1 Word Recognition

Word recognition is the ability of a reader to recognize the written words accurately and virtually effortlessly. Word recognition is sometimes referred to as "isolated Word recognition" because it entails a reader's ability to recognize words individually from a list, for example without the benefit of surrounding information for contextual help (LINCS, 2018). Word reading development involves the interrelation and integration of phonology (sound), orthography (visually), and semantics (meaning) (Harm M. W. & Seidenberg, 2004; Plaut D. , McClelland, Seidenberg, & Patterson, 1996). Usually, word recognition is performed in two ways, by recognizing whole words or parts of words "at sight" and through phonological decoding (Ehri, 2002). As learners become more proficient at reading, they can recognize more words instantly and automatically, and reading becomes fluent. Essentially, fluent readers have larger "sight word" vocabularies (Torgesen, Rashotte, Alexander, Alexander, & MacPhee, 2003; Denton & Otaiba, 2011). Reading fluency is not only influenced by the speed of word recognition, but also by the reader's ongoing comprehension of the text, and fluent readers can interpret the phrasing and inflections in the text appropriately, (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Denton & Otaiba, 2011)

Over the last thirty years, a number of word recognition models have been proposed, including Interactive Activation (McClelland & Rumelhart, 1981), Activation Verification (Paap, Newsome, McDonald, & Schvaneveldt, 1982), Multiple Levels (Norris, A quantitative multiple-levels model of reading aloud, 1994), Multiple Read-Out (Grainger & Jacobs, 1996), Multiple Trace Memory (Ans, Carbonnel, & Valdois, 1998), Connectionist Dual-Process (Zorzi, Houghton, & Butterworth, 1998), and Bayesian Reader models (Norris, 2006). However, the two models that have received the most attention from researchers are the Dual Route Cascaded model (DRC) (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), and various parallel distributed processing or connectionist versions of what have become known as triangle models (Harm & Seidenberg, 1999; Harm & Seidenberg, 2004; Plaut D. , McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989). Also, these models can be defined as "reading models" by designers (Rayner & Reichle, 2010).

2.2.1.1 The Word Recognition Model

Cattell was the first psychologist who proposed the word recognition model. The word recognition model is the oldest model in the psychological literature and is likely much older than the literature. The word recognition model says that words are recognized as complete units. The claim of the model is that we see words as complete patterns rather than the sum of letter parts. Another claim is to use the envelope created by the outline of the word to identify the word (See fig.1). Cattell supported the model because it provided the best explanation of the available experimental evidence but, after that, Catell Discovered a fascinating effect that is called the Word Superiority Effect.

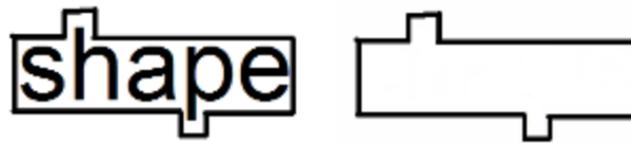


Figure 1 Word shape recognizing using the envelope cited from (Larson K. , 2017)

2.2.1.2 Word Superiority Effects

The word superiority effect (WSE) is a term explained by James Cattell (1886). WSE is that the probability of defining a single word with a single letter is high. Reicher (1969) found that the letters in words are recognized more accurately than both single letter and non-words. The findings based on this hypothesis were based on the fact that the letters of the reading are recognized more correctly than both single and nonsensical words. However, other studies have found that the meaningless words, which cannot be pronounced, are better known (Aderman & Smith, 1971; Baron & Thurston, 1973; McClelland & Johnston, 1977; Carr, Davidson, & Hawkins, 1978). It is suggested that superiority is a result of letter combinations, not as a consequence of known word patterns (Beier S. , 2009). The general short definition of the the Word Superiority effect refers to the phenomenon that people have better recognition of letters presented within words as compared to isolated letters and to letters presented within a nonword (orthographically illegal, unpronounceable letter array) strings (Starrfelt, Petersen, & Signe, 2013).

2.2.1.3 Dual Route Cascaded (DRC) Model

The DRC model is a computational reading model that aims to explain how skilled readers perform certain basic reading tasks. The abbreviation emphasizes the two basic characteristics of the model (Coltheart M, 2001): A Dual Route model, and the model information is cascaded within the process (Carr & Pollatsek, 1985). DRC is the most

comprehensive theory of visual word recognition and loud readings ever described and has been extensively studied (Coltheart et al., 2001). The model retains the processing and selection mechanisms of the interactive-activation model (See, page 12), which have been so successful in the understanding of visual word recognition. The lexical decisions in the model are based on the activation analysis of the nodes in the orthographic lexicon (Rastle, 2016). The model consists of three routes, lexical semantic route, lexical non-semantic route, and grapheme–phoneme conversion (GPC) route. Each route consists of a series of interactive layers. These layers contain a number of units. Units represent the smallest individual symbolic parts of the model, such as the words in the orthographic lexicon or letters in the unit layer. There are two ways in which units in different layers can interact. One is that the activation of one unit makes it more difficult to increase the activation of the other units. The other is through excitation, where the activation of a unit contributes to the activation of other units. Coltheart (2005) mentions that units may also interact on the related level through lateral inhibition (See fig.2).

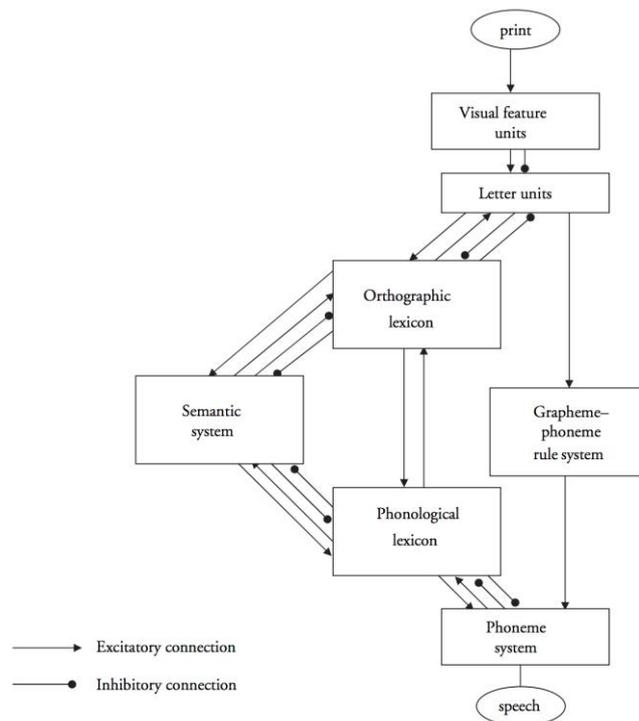


Figure 2 Dual Route Cascaded model (DRC) (Coltheart M. , 2005)

In other words, the decision of which route to use is based on properties of the word itself. When the word is familiar or contains irregular mappings from orthography to phonology, readers use a “direct route,” and access a semantic representation directly from an orthographic representation.

“When the word is less familiar readers use a phonologically mediated route. readers activate first the phonological information and subsequently access a semantic representation from the phonology (orthography to phonology to semantics). (Polse & Reilly, 2012). The phonological route can be compared to “sounding out” a word, as comprehension is thought to come from the sound, rather than directly from the written (orthographic) representation. (Polse & Reilly, 2012, s. 47).

Connectionist or cascaded models suggest that comprehension of a written word is accomplished by an increased sensitivity to the statistical structure that exists between orthographic, phonological, and orthographic representations. Such model is the Triangle Model (Polse & Reilly, 2012).

2.2.1.4 *The Triangle Model*

The Triangle model ⁵ is a connectionist model. The Triangle model suggests that there is both a pathway from orthography to phonology and a path from semantics back to orthography and phonology (Polse & Reilly, 2012). Implementations of the model include both ways and all representations for the computation of all elements, regardless of their lexicality, familiarity or frequency. Because the phonological path is more direct, it is thought to be faster and contributes to reading aloud from the semantic path (Nation K. , 2009).

2.2.1.5 *Interactive Activation (IA) Model*

McClelland and Rumelhart (1981), (1982) have developed a word perception model called Interactive Activation (IA) Model. The central feature of this model assumes the processing of information during reading is made up of a series of levels corresponding to visual characteristics, letterforms and words. This model is used to describe the word superiority (WSE), which expresses a phenomenon that people can more easily distinguish between letterforms (Chase & Tallal, 1990). In the interactive activation model, information from visual stimulus flows through feature, letterforms, and word levels of representation. Each of these levels of representation consists of individual units called nodes. The connections between these adjacent levels of representation are both excitatory

⁵ (Plaut D. , McClelland, Seidenberg, & Patterson, 1996; Harm & Seidenberg, 2004; Polse & Reilly, 2012)

and inhibitory: the nodes at each level are the stimulation nodes in adjacent levels where they inhibit nodes at adjacent levels where they are consistent and inconsistent at adjacent levels. For example, the first letterforms in a stimulus will activate word nodes for TAKE, TALL and TREE while blocking word nodes for CAKE, MALL and FREE. The information moves continuously (i.e. in “cascade”; McClelland J. L., 1979) through these levels of representation (Rastle, 2016).

"The crucial feature of the interactive activation model is that it postulates two-way connections between semantic, phonological, and orthographic bodies of knowledge. These two-way connections provide an opportunity for phonological and semantic information to influence the rise of activation of nodes in the orthographic lexicon. For example, the stimulus COAT will activate its own node in the orthographic lexicon through feedforward activation from the letterforms nodes. However, the orthographic node for COAT will also receive supporting activation from semantic nodes (activated via phonological nodes and/or via orthographic nodes) and from phonological nodes. Though semantic and phonological information can influence the rise of activation in orthographic nodes, an important claim of this model is that neither semantic nor phonological information is a necessary condition for the recognition of a printed word." (Rastle, 2016, s. 77)

2.2.2 Letterforms Recognition

The two fundamental theories of letterforms identification are the template-matching and feature-comparison theories. The template-matching theory is defined as a holistic approach in which characters are perceived as a whole, and the feature-comparison theories is a more analytic approach that separates characters into different elements in the perception process (Beier S. , 2009).

2.2.2.1 Template-matching Theory

The fundamental idea of the template-matching theory is that for each character of the alphabet, a primary form of templates is stored in the brain. When the brain detects a new shape, it selects the most appropriate one from a set of character templates (Hunziker, 1998). However, the main question of template-matching theory is, how the brain is perceiving a wide range of thousands of handwriting and typefaces (Naus & Shillman,

1976; Crowder & Wagner, 1992; Rayner & Pollatsek, 1989; Underwood & Batt, 1996; Smith, 2004; Beier S, 2009).

2.2.2.2 *Feature Comparison Theory*

The idea of the feature-comparison theory is that the brain decodes the different features of the character individually. In an experiment supporting the feature-comparison made by Neisser, Neisser found that it is easier with a search task to locate the character ‘z’ in a group of visually unrelated characters (**odugqr**), than in a group of related characters (see fig.3).

Additionally, support for the feature-comparison theory has been validated by a study conducted by Pritchard (1961). Pritchard found that complex stimulation sometimes stood out and re-emerged as a whole, and sometimes disappeared. That shows both template-matching and feature-comparison theories are interrelated. But today both theories combine and expand with the Parallel Letter recognition model, which gives us a chance to use both theories in one model.

ODUGQR	IVMXEW
QCDUGO	EWVMIX
CQOGRD	EXWMVI
QUGCDR	IXEMWV
URDGQO	VXWEMI
GRUQDO	MXVEWI
DUZGRO	XVWMEI
UCGROD	MWXVIE
DQRCGU	VIMEXW
QDOCGU	EXVWIM
CGUROQ	VWMIEX
OCDURQ	VMWIE X
UOCGQD	XVWMEI
RGQCOU	XMEWIV
GRUDQO	MXIVEW
OCURDO	VEWMIX
DUCOQG	IVWMEX
CGRDQU	IEVMWX
UDRCOQ	WVZMXE
GQCORU	XEMIVW
GOQUCD	WXIMEV
URDCGO	EMWIVX
GODRQC	IVEMXW

Figure 3 Lists for visual searching. The target is ‘z’ in both lists (Neisser, 1967, p.70; Beier S. , 2016 p.36).

2.2.2.3 *Parallel Letter Recognition Model*

The most widely adopted model by psychologists is the parallel recognition model. The most of the studies reviewed so far fit the basic ideas of the Parallel Letter Recognition (PLR) model (McClelland & Johnston, 1977; Rayner & Pollatsek, 1989; Larson K. , 2004). The model contains three basic levels which are word detection, feature detection and letter detection. The first step of processing is recognizing the features of the individual letters, such as curves, diagonal lines, and horizontal lines (feature detectors level). These features are then sent to the letter detector level, where each of the letters in the stimulus words are recognized simultaneously. If a ‘d’ is part of the stimulus material, the letter detectors for ‘d’ would be active in combination with other related shapes like ‘p’ and ‘b’. With letter detectors, the letter level then sends activation to the word detector level (third level). ‘D’ in the first letter detector position sends activation to all words related to ‘D’ (DART and DARK) in the first position. ‘A’ in the second letter detector position sends activation to the all of the ‘A’ words, (O, DART and DARK) and word

detectors choose the most related word according to the stimulus letter combination (Larson K. , 2004). A variation of the model is identified as the interactive activation model by McClelland & Rumelhart (1981); and Rumelhart & McClelland (1982). What happens further on the word detector level is not completely known. In addition, the process of processing the PRL model downwards and towards allows the WSF effect to be explained (Beier, 2009, s. 42).

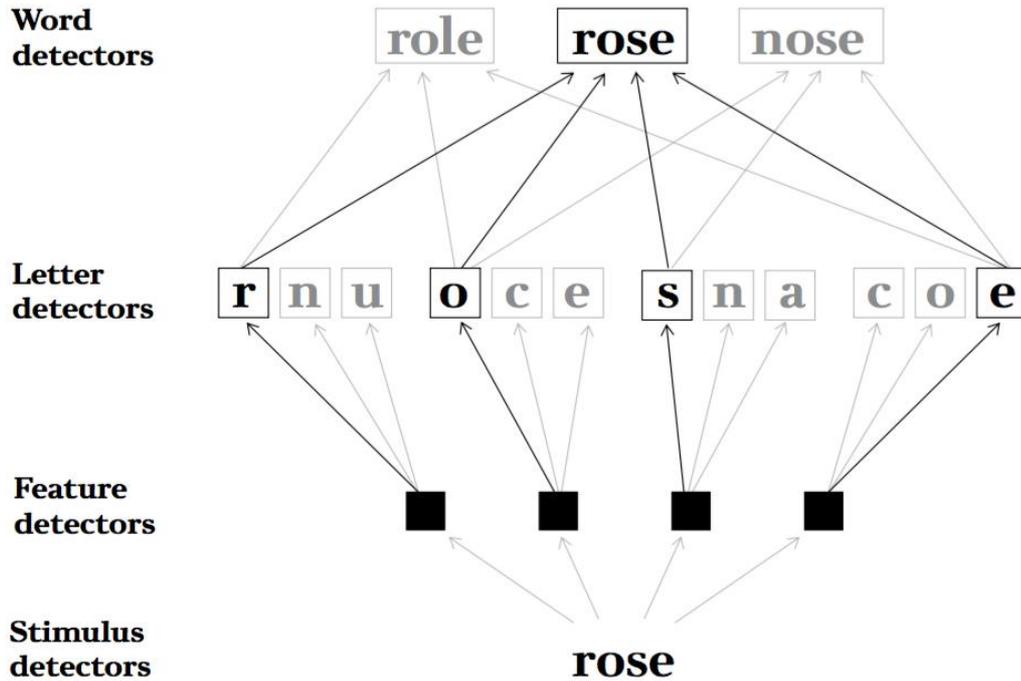


Figure 4 Parallel Letter Recognition Model based on the model presented by Rayner & Pollatsek (1989) (Beier S. , 2009, s. 41)

Pelli & Tillman conducted a new study which looked at different aspects of the internal relation between different processes affecting the reading process. The researchers tried to distinguish three mental processes. Letter-by-letter (L), word-wholes (W), and sentence-context (S) recognition). Reading speed, audible and silent reading has been tested using a fast-visual presentation. The results show that these three processes functioned individually in coordination with each other (Pelli & Tillman, 2007; Beier S. , 2009). According to S. Beier (2009), the incorporation of the ideas of the Pelli & Tillman and PLR models has been a good indication of the different kinds of operations that involves in the reading process.

2.2.3 Learning to Read

Learning to read is a complex task. In an alphabetical language such as English, the child's first step is to "crack the code" and understand the alphabetic principle⁶ (Byrne, 1998; Gough & Hillinger, Learning to read: An unnatural act. , 1980; Snowling & Hulme, 2011). But learning to decode the print is not everything about reading. To be a proficient reader, the child must be able to decode the print and understand correctly the text (Treiman & Kessler, 2005; Fletcher, Lyon, Fuchs, & Barnes, 2007; Snowling & Hulme, 2011). Learning to read is described by Gough and Turner as two basic processes. Firstly, to learn how to convert the characters into the words, and secondly to comprehending the meaning of the word. The first process can be taught through phonetics (Vaughn & Linan-Thompson, 2004). Most children come to the task of reading with a well-established system to handle the spoken language. The difficulty that parents and teachers face is how these oral language (OL) skills are best used in service of reading, and this is based on a theory of how literacy develops. A large amount of evidence shows that the best predictors of learning to read in the first stage are measures of letter-sound knowledge and phoneme awareness (Bowey, 2005; Muter, Hulme, Snowling, & Stevenson, 2004; Snowling & Hulme, 2011) Both of these skills use the phonological system of language (Muter, Hulme, Snowling, & Stevenson, 2004).

Beyond the early stages of reading, children need to improve their reading fluency. However, little is known about how reading skills become automatized in children. A simple conceptualization of reading is a mapping process between oral language and print. It is a process where the letterforms on the page are converted into sounds with connections to meaning, and automatization depends on how often these mappings are used. According to this view, oral language is a precursor of literacy development and children with language difficulties are at high risk of reading problems (e.g., autism) (Snowling & Hulme, 2011). The National Reading Panel (NRP) identified five essential components of

⁶ The National Reading Panel has reviewed 38 studies on teaching phonics and found that it has a clear benefit for young children to learn to read, the students who have taught the students to voice have made faster early progress and ended up with higher reading achievement (National Reading Panel, 2000). In addition, the NRP found that from 52 studies, phonemic awareness training provided children with a clear learning outcome. The Panel has decided that it is critical to carefully coordinate the teaching of these skills to ensure that phonemic awareness and phonetics are both taught and that students have made the most progress in school. The National Early Literacy Panel validates the value of phonemic awareness teaching for young children (2008).

reading: phonemic awareness⁷, phonics⁸, oral reading fluency⁹, vocabulary and comprehension strategies. These components are now widely recognized as essential for effective literacy instruction for all students (National Institute of Child Health and Human Development, 2000). We can separate components in two groups, first code-focused skills; Phonemic awareness, phonics and fluency, which are required to accurately and fluently identify words in the text. The second group is comprehension strategies and vocabulary.

2.2.4 Reading and Autism

One of the most important processes of reading the text is to understand and define each word; decoding deficits emerge when this process has not been done correctly. The correct reading is also related to the processed voice and correct pronunciation of the characters. For this reason, there is a connection between reading and phonological processes. It is not possible to come to a definitive conclusion from the studies directed towards individuals with autism, because the literature review showed that the reading processes of the individuals with autism vary widely (Fernandes, de La Higuera Amato, Cardoso, Navas, & Molini-Avejonas, 2015). Even if it is not possible to come to the definitive conclusion, we can separate individuals with autism reading abilities into the three groups. These are the children who read fluently but have difficulty in comprehension of text (Newman, et.al, 2007), children who have problems with word decoding (Arciuli,

⁷Phonemic awareness is the understanding that spoken words and syllables are themselves made up of sequences of elementary speech sounds, or phonemes, and the ability to manipulate them. Phonemic awareness is the key point for the child to learn to read. (V. Zygouris-Coe, 2001) Students with limited phonemic awareness will have difficulty acquiring the alphabetic principle, which will limit their ability to decode words, (Blachman, 1991; V. Zygouris-Coe, 2001) and will not benefit from phonics (Juel, C., 1986; V. Zygouris-Coe, 2001). It is concluded that the two best elements of reading success are alphabetical principles and phonemic awareness by Adams (1990). Studies about phonemic awareness show that the phonemic awareness is an essential factor, but it alone will not be enough to guarantee reading success (Lyon, 1997). If students able to identify the letter sounds and read basic words in early reading, they can get more likely better to read in the future. (Hosp et al, 2007; Booker, 2013) Phonemic awareness is the critical components to learn the reading (Chapman, 2003; Booker, 2013). Phonemic awareness focuses on the sounds of the phonemes, this process helps to increase decoding and reading skills. (Booker, 2013)

⁸Phonics is understanding letter-sound correspondences in reading and spelling. Phonics is the process of converting printed words to oral language. According to the Adam, phonics is "a system of teaching reading that builds on the alphabetic principle, a system of which a central component is the teaching of correspondences between letters or groups of letters and their pronunciations" (1990, s. 50). The Childs meet with letters in this stage and learn the sound of the letter. To learn the phonics, students have to determine the relationship between letters and sounds connection, and then remember the exact letter patterns and series that represent various speech sounds (Moats, 2000; Vaughn & Linan-Thompson, 2004). The phonics, include letter-sound relationships and sound-symbol associations. (Lane & P. C. Pullen, 2004)

⁹Fluency is the ability to read text as well as we talk and to interpret the text without having to stop and solve every word. The findings of the National Reading Panel conclude that guided verbal reading and repeated verbal reading have a meaningful and positive influence on vocabulary recognition, fluency, and comprehension of reading in all ages.

2013; Nation, 2006; Åsberg, Dahlgren, & Dahlgren Sandberg, 2008; Åsberg, Kopp, Berg-Kelly, & Gillberg, in press) and children who are involved in both groups (Fernandes F.D.M, 2015). The student with ASD need special teaching in literacy compared to student without autism (National Research Council, 2001). Different interventions and approaches have been used for these three groups. The current literature showed that the interventions are limited. So, it has been proposed to develop new research and training strategies on the individual with autism (Kelly J. Whalon, 2009).

2.2.5 Reading Education of Individuals with Autism

Reading education is necessary for all students (Kliewer & Landis, 1999; Laz, 2009). In modern education the expectation is that all students can gain some reading skills. Children with autism defect in the mental capacity and focus necessary to learn how to read and develop reading comprehension may take longer than normal children do. Although some students with autism cannot achieve full academic literacy, functional literacy is essential for them to live, and work (Alberto, Fredrick, Hughes, McIntosh, & Cihak, 2007).

According to Koegel (2006), only about half of students diagnosed with autism can acquire strong communication, and language intervention strategies are time and labor intensive for both students and teachers. The National Research Council (2001) identified two significant communication deficits in children with autism: joint attention and symbol usage. Joint attention leads to the ability to coordinate attention between people and objects. Symbol usage relates to shared meanings for symbols. Both, joint attention and symbol usage significantly affect the way students with autism learn the language (National Reading Panel, 2000; Laz, 2009) and thus literacy skills. The main educational strategy and treatment method for children with autism is the Association of Behavior Analysis (ABA,) and published approaches to teaching reading such as The Nonverbal Reading Approach, Reading Mastery™, The Reading and Writing Program, Augmentative and Alternative Communication, Cued Speech and Visual Phonics (Laz, 2009).

In the majority of cases children with ASD have difficulty with verbal instruction. Children with ASD that can be visual learners, and children that lack the natural language ability to derive meaning from spoken words.

With autistic and PDD children in particular the language channel is often the weakest. This is often the case with children who seem able to tune out much of the language addressed to them, and do not easily learn new words just by hearing other people

use them (Siegel, 1996, s. 242-243). They tend to be visual learners living in a very auditory world (Hodgdon L. , 1999, p. 65).

Schreibman (1988) notes that 50% of individuals with autism are functionally silent (pp. 106). Bondy and Frost (1995) estimate this figure as high as 80% (pp. 322). According to Hodgdon, this lack of effective communication, in other words communication difficulties, is one of the major deficiencies of children with autism and can be a primary reason for many behaviour problems (Quill, 1995; Hodgdon, 1995a; Hodgdon L. Q., 1995b; Quill, 1998; Hodgdon 1999). The major cited example of this in the literature is aggression (See for example; Koegel and Koegel 1995; Hodgdon 1995b). Even if communication difficulties made it hard to learn to read for the children with autism, there are visual strategies for these difficulties. Visual strategies are effective with children with autism and through their life.

2.2.5.1 Visual Strategies

Visual strategies are used both in children who have language deficiency and communication (Cohen, 2007). If the child struggles to talk or has difficulties in oral language, teachers prefer to use the Material Based System (Tissot, 2003). But for all children with autism, the use of visual strategies has a significant effect on their learning (Meadan, Fettig, Ostrosky, Michna, & Triplett, 2011).

The Materials based system consists of The Nonverbal Reading Approach, Nina Lovaas' Reading and Writing system, PECs (or other icon-based systems) and TEACCH (Tissot, 2003). TEACCH method was developed by Professor Eric Schopler and many of his colleagues at the University of North Carolina at Chapel Hill. The TEACCH method provides the individual with structure and organization. This method relies on five basic principles. The structure includes educational and therapeutic goals that are Physical structure, Scheduling, Work (Activity) systems, Routine and Visual structure.

The most remarkable program of the material based system is the Reading and Writing program which developed by Nina Watthen-Lovaas. The program was developed for children with autism who do not benefit from Applied Behavior Analysis (ABA) and verbal instruction. The

The Reading and Writing program is very comprehensive, but a short description of the program is as follows; it uses pictures to communicate with children and teaches the child to read words by matching these with images. Lovaas developed this program when she noticed that some of the children who did not profit from the traditional ABA-program

were visually very strong (for example, they can put puzzles together that were at a level higher than their developmental age would suggest). So, they started first with a character matching and word matching system. They found that for most of these children it was enforcing in itself to match letterforms. In the beginning, they thought it would be difficult for the child, but after a short training period, children showed success in reading at a simple level. Even if that is a word reading and includes small mistakes, it has shown the success of the program and the potential of children (Watthen-Lovaas, 2004).

Reading Writing Program has some strategies that are as follows:

- Teaching Expressive Language
- Matching letterforms
- Matching Printed Words
- Early Reading Tasks (Identifying 2D Objects)
- Reading (Responding to Printed Instructions)
- Copying Words
- Writing Object Labels
- Writing Sentences (Labeling 2D Objects)
- Early Abstract Writing (Observations), (Requests)
- Early Abstract Reading (Identifying 2D Colors, size, Labeling 2D Size and 3D Size)
- Writing Phrases (Color/Noun)

These strategies show us how student with autism learn letterform and word identification (see fig. 5,6). Our topic is concerned with Matching Letters and Matching Printed Words, therefore, we didn't explain the other strategies, for example 'Writing Object Labels'.

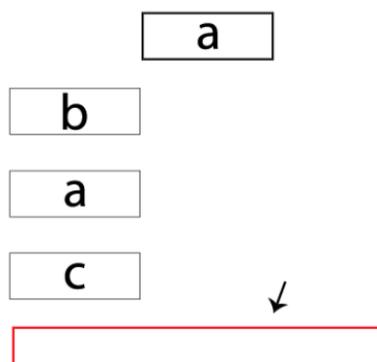


Figure 5 Matching Letters

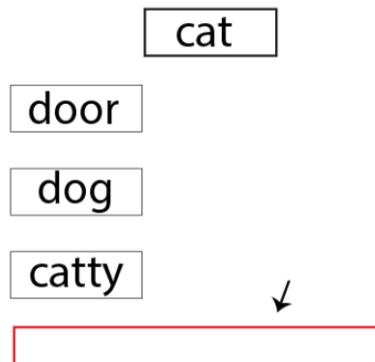


Figure 6 Printed word matching

The picture exchange communication system (PECS) is a pictorial system developed for children with social communication deficits (Frost & Bondy, 1994). PECS System uses small cards to represent items the child wanted (favoured toys or food items). Pictures are held in a notebook (PECS card). The child communicates using PEC cards (e.g. 'fruit juice' card near the 'I Want' card). PECS is designed to answer a child's requests (for visible and invisible items), to answer questions (for example, 'What do you want?') And to make social comments (for example, I see " [object] ").

Nina Watthen-Lovaas described the differences between the PECS and The Reading and Writing Program as "PECS might be the only alternative for children with massive communication problems. We have children who could never learn to match a word to word and never will understand the connection between an object and a written word. For them, the symbols (PECS) would be the only alternative to learn some the communication (Watthen-Lovaas, 2004).

According to symptoms of the children (IQ, age, several and learning disabilities), different approaches are used by teachers (Kelly J. Whalon, 2009). However, The National Reading Panel (NICHD, 2000) are cited in NCLB language requiring that all students (including those with autism) have been provided explicit and systematic classroom reading instruction that includes five essential components of reading: phonemic awareness, phonics, oral reading fluency, vocabulary and comprehension strategies. Linda Laz (2009) has explained the challenges of teaching reading to students with autism in the six titles; language deficits, behavioral challenges, cognitive ability lack of early reading opportunities, the school experience, and literate communities. These challenges ensure that learning to read is delayed and transformed into a long process specific to children with autism. Using a typical reading readiness model may not be effective for students with autism (Lanter & Watson, 2008). NRC suggested that educational interventions must be highly individualized and capitalize on the student's specific skill strengths (National Research Council, 2001). Therefore, many students with autism require personalized education (Laz, 2009). It's clear that to teach literacy skills to students with autism takes a long time, and effective education requires creativity by the special educator. In addition, the emerging literature shows that there are many programs, strategies, and interventions that have been created to efficiently teach reading to student with autism, but the current research is still limited (Kelly J. Whalon, 2009).

2.2.5.2 Using CBU of Reading Education

The Impact of Multimedia Graphic and Text with Autistic Learners in Reading was investigated by the Sarah Omar, Azman Bidin (2015). Sarah Omar, Azman Bidin investigated the reading process of the autistic learner by three question which are;

1. *Can graphics with the text help young children to improve their reading skills?*
2. *Can colors lead to better attentiveness with autistic learners?*
3. *Does the computer-based intervention program increase and improve autistic learner's abilities to read?*

The result of the investigation shows that there is a strong relationship between CBU and multimedia on the process of learning to read. Presenting the text with visual elements ensured that individuals with autism learned and understood the meaning of the words. This study has shown the big impact of text and visual elements on individuals with autism. Also, the study has suggested which font and point sizes to use on autism (Omar & Bidin, 2015).

2.2.5.3 Reading Difficulties of The Children with Autism

Previous research demonstrated that poor language skills predicted poor reading abilities reinforcing the strong association between language and reading components (Davidson & Weismer, 2014; Dickinson, Golinkoff, & Hirsh-Pasek, 2010; Jacobs, 2013; McIntyre, et. al., 2017; Storch, 2002; Tager-Flusberg & Joseph, 2003; Åsberg, Kopp, Berg-Kelly, & Gillberg, 2010). In addition, emerging research proved that reading is negatively associated with ASD and symptom severity (Åsberg, Kopp, Berg-Kelly, & Gillberg, 2010; McIntyre, et. al., 2017; Norbury & Nation, 2011; Ricketts, Jones, Happé, & Charman, 2013). Amanda Nally et al. (2018) concluded that children with ASD have the most severe deficits in phonemic awareness, and language skills, which was consistent with other research (Dydia, Brock, Justice, & Kaderavek, 2017; Gabig, 2010; Whalon & Hart, 2011), and suggested more intensive reading instruction for more severe symptoms with ASD.

Åsberg and Sandberg examined word reading skills and reading-related language and cognitive correlates in Swedish 10–15 year olds with ASD (2010). The full group with ASD did not differ statistically from an age-matched comparison group in word reading, but a poor-readers subgroup was identified who displayed severe difficulties. Normal readers with ASD did not differ from the comparison group in nonverbal ability, phonological processing, rapid naming or receptive vocabulary. The poor subgroup

performed below on all measures except nonverbal ability. When poor readers with ASD were matched for reading level with younger readers, no difference was found on any reading-related skill. Furthermore no significant correlation was found between autistic symptomatology and word reading within the ASD group. It is concluded that the pattern of individual differences in word reading among children with ASD conforms well to that seen in children without ASD of normal or delayed reading abilities, and the profile of the poor reader's group with ASD conformed to a 'normally impaired' reading pattern (Åsberg & Sandberg, 2012).

2.2.5.4 *Learning Disabilities*

Autism and learning disability are co-associated. Also, autism is more prevalent among individuals with learning disabilities. Many of the autistic behaviors coincide with behaviors common to learning disabilities. In a comprehensive compilation of 23 studies on autism epidemiology, Fombonne (1999) found that 19.4% of people with autism functioned within the normal range of intelligence, 29.4% of people with autism had moderate and moderate learning disabilities, and 41.9% were severely learning disabled. These results should be carefully examined, due to differences in methodology, assessments and IQ bands, but this is a good indicator of the level of learning disability in the autism population (O'Brien & Pearson, 2004).

As a result, it can be that there is a relationship between the reading difficulties of people with autism and other disabilities. It means, the reading difficulties of autism can occur by the learning disabilities, low IQ, and autism symptoms. Dyslexia is a learning difficulty. But the difficulty of reading on individuals with autism does not overlap with the dyslexic profile (Åsberg & Sandberg, 2012). For this reason, addressing the difficulties of dyslexia while creating a new typeface, will not help solve the problems of individuals with autism, Therefore, we can focus on the learning disabilities (related to the IQ) and the ASD symptoms to help the autism population. But the previous research is scant to create a typeface for autism.

2.3 Typography

2.3.1 *Legibility and Readability*

Legibility and readability are two different subjects. While legibility is a typographic term, which is concerned with the perception of the letterforms (glyphs) in the

text, readability describes the combination between layout and typography (Ifra Research, 2000).

Over the last century, many researchers have been interested in the readability of printed objects. There were many suggestions for rules about readability, but they were not based on scientific studies and were based on subjective findings and partly on the basis of art harmony. Very little work has been done in the 19th century (Weber, 1881; Javel, 1881; Cattell J. , 1885; Javel, 1881). But after the first quarter of the 20th century, the researchers developed their work in the area (Messmer, 1904; Pyke, 1926; Tinker & Paterson, *Typography and legibility in reading.*, 1950). M. A. Tinker and R. L. Pyke are the first researchers who established the term 'Legibility' avoiding another term known as 'readability' which deals with the ease of reading text.

Nowadays, with the increase of digital devices and internet usage, readability has become one of the important topics of our time. Today developers designers have been using the readability and legibility principles to retain visitors to their websites. Also, Google has rules about readability, if a website does not follow the readability rules, Google reduces the visibility rate of the website from the google list (Goggle, 2018). Designers and researchers have designed a website with the principles of readability, legibility and easy comprehension for individuals with autism. This is an example of how readability and legibility are both important for people with special needs (more information see page 33).

According to Pardo, the content of the text, the readability of the text, and the font features influence the interaction between the reader and the text. Different typefaces have different connotations and can have an influence on the readability, interpretation, and words they represent (Thangaraj, 2004).

Tracy, defined legibility as follows: "we want the word to mean the quality of being decipherable and recognizable [...] legibility is the term to use when discussing the clarity of single characters" (Tracy, 1986, p.31).

Tracy goes on defining readability: "[It is as] if the columns of a newspaper or magazine or the pages of a book can be read for many minutes at a time without strain or difficulty, then we can say the type has good readability" (Tracy, 1986, p.31).

2.3.1.1 Readability

Readability is about whether or not the text easier to read. Edgar Dale and Jeanne Chall said about readability: "The sum total (including all the interactions) of all those

elements within a given piece of printed material that affect the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimal speed, and find it interesting.”

Readability is influenced by:

- Choice of legible typeface or font: Font style, body size, weight. Poorly designed fonts and those that are too tightly or loosely fitted can seriously impair readability. Appropriate kerning can also increase readability.
- Line spacing: Is spacing too tight or too loose? Readability can be improved when generous vertical space separates lines of text, making it easier for the eye to distinguish one line from the next, or previous line.
- Line length: Research has found that the physiognomy of the eye means that the eye tires if a line requires more than three or four saccadic eye movements.
- Column spacing for clear separation of text columns.
- Justification and text alignment (design of right-hand edge) and hyphenation and its appropriate use in lines of different lengths.
- Tracking or letterforms and word spacing.

2.3.2 Legibility

Legibility is the term used when discussing the clarity of a single character (Tracy, 1986). The visual properties of a character or symbol determine the ease with which it can be recognized (Zuffia et al., 2007). If the legibility is poor, we can have difficulty distinguishing the character from others. The legibility of a character has several factors these are x-height¹⁰, character shapes, weight, counters¹¹, stroke contrast, serifs or terminal (Tinker, 1963; Poulton E. , 1972; Reynolds, 1979). These attributes can be interpreted to improve typefaces legibility or not (fig.7).

¹⁰ X-height refers to the height of the lower case “x” in a typeface. It is often a better indicator of the apparent size of a typeface than point size (Poulton, 1972 ; Bix, 2002).

¹¹ The white shape, counters within the letters help to define characters according to the Typographers. Large counters are an aid to character recognition.

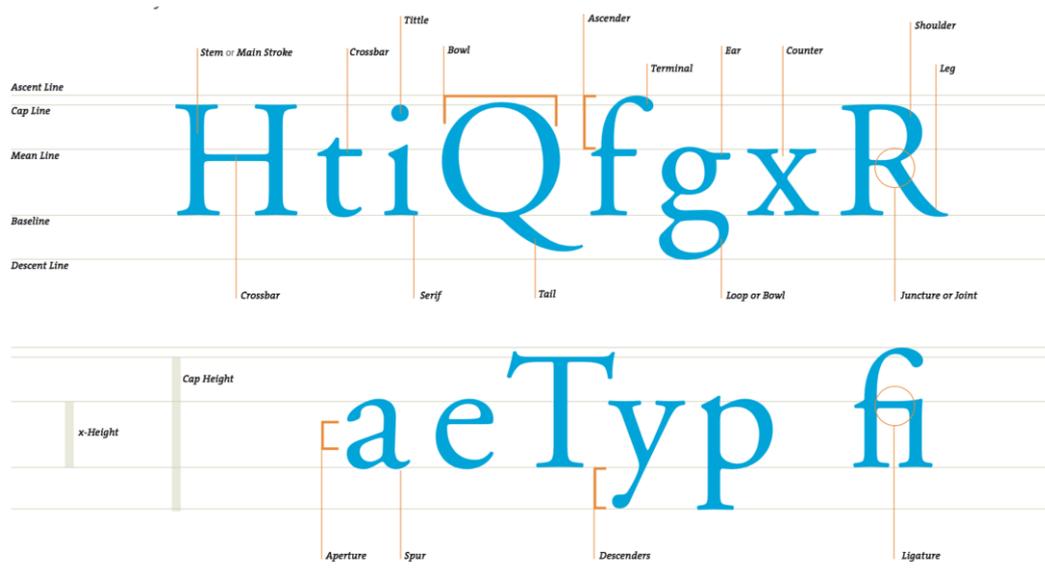


Figure 7 Typeface Anatomy (Samara, 2004)

2.3.2.1 Open Counters

Designers have often said that open counters are a good factor for legibility. Actually, science has supported this idea. Researchers compared individual letterforms with each other, the results showed that open counters have a positive effect on legibility (Sheedy, Tai, & John Hayes, 2006). In the study, researchers took different typefaces and compared the individual letterforms with each other. You can see on the green row the legible characters. It shows that open counters are an important factor in legibility (Beier S., The legibility of letters and words, 2016; Sheedy, Tai, & John Hayes, 2006).

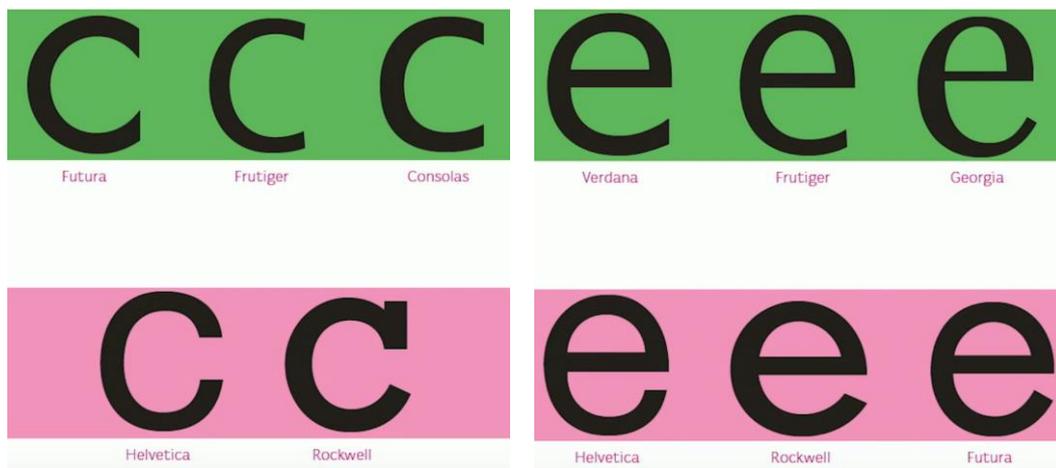


Figure 8 The legibility of letters and words, Sofie Beier, ATypI 2016 Warsaw, Poland (Sheedy, Tai, & John Hayes, 2006).

2.3.2.2 Width

Sofie B. & K. Larson (2010) examined how the narrowness and width on characters affected legibility. They compare two typefaces (Spencer & ovnink) and they found that the wide letters were more legible than narrow ones. Besides these findings, they found if the narrow "t" and "c" letters become wider it can eliminate a common cause of misreadings (see fig. 9) (Beier & Larson, 2010; Beier S., 2009).



Figure 9 (Beier & Larson, 2010; Beier S. , *The legibility of letters and words*, 2016)

Even if the wider typefaces are more legible it takes more space on screen or printed, and therefore it's not usable at all. You can see the same body point size typefaces in Figure 11. You can understand why we can't use the wider typeface. You have limited horizontal space on print or on screen, which eliminates the benefit of the wider letterforms (Beier S. , 2016).



Figure 10 wider character comparison (Beier S. , 2016)

2.3.2.3 Serif or Sans-Serif

There is a great deal of information about serif and sans-serif typeface. The researchers have pointed out that there is no difference between reading the serif or sans-serif typefaces (Paterson & Tinker, 1932; Poulton C. E., 1965; De Lange, Esterhuizen, &

Beatty, 1993). Also, some researchers advocate for the superiority of serif typefaces (Burt, 1959; Weildon, 1995). The decision whether to use serif or sans-serif is best determined by the context of their use. Because many factors that have an effect on legibility it is therefore difficult to settle on a conclusion. In addition, Sofie B. and Mary Dyson had an interesting investigation about the use of serif vs. sans-serif. They took a typeface and added serif elements to the typeface and tested the legibility of both typefaces. They found that the vertical extremes of serifs actually help legibility at distance reading, so this is an example where the role of serif may come into play. (Beier, 2009; Beier & Dyson, 2014). In the legibility studies sometimes misreading becomes the major topic. Misreadings occur with either poor perception of the letterforms themselves or confusing the letterform with that of another letterform. For this reason, the researchers attempted to identify the letters most likely to cause misreading on that basis (Beier S., 2016).

2.3.3 Errors

Previous legibility research usually studied the legibility of letterforms by comparing the different characters within the alphabet. Seven studies on the matter carried out (1964, as cited in Beier, 2009), were summarized by Tinker (1964). Tinker found a pattern in the seven studies concerning the legibility relationship between the letters. He defines the relation as below;

High legibility letterforms: d – m – p – q – w

Medium legibility letterforms: j – r – v – x – y

Low legibility letterforms: c – e – i – n – l

Tinker's research was very beneficial to researchers during the early stages of legibility research. Letter recognition studies tend to find similar error patterns (Geyer, 'Recognition and confusion of the lowercase alphabet', 1977; Bouma, 'Visual recognition of isolated lower-case letters', 1971; Tinker, Legibility of Print, 1963). There are two main character groups with high error rates. One is made up of the standard width x-height characters formed by an e-c-a-s-n-u-o of straight and curved lines. The other group consists of a single vertical stroke and (i-j-l-t-f) narrow letterforms. Researchers investigated the misreading of small characters in five different studies to confirm which letters were problematic, which gives us a chance to also learn the effects on autism (see fig.11).

Researchers	Sanford (1888)	Bouma (1971)	Tinker (1928)	Sanford (1888)	Geyer (1977)	Bouma (1971)	Dockeray (1910)
Test methods	Distance	Distance	Short exposure	Short exposure	Short exposure	Short exposure	Parafoveal vision
Typefaces	Old Style Roman	Courier	Didone Style	Old Style Roman	Tactype Futura	Courier	Old Style Roman
* Highest frequency of mistaken at top ** No specific order	*	*	*	*	*	*	**
Misreadings	y → p i → l w → v h → b m → w b → h p → r n → a h → k t → i e → c l → i f → r l → j k → x c → e o → c v → r q → g y → r j → l m → u c → o	l → i g → q m → n w → v e → o i → l c → e h → b b → h r → f z → i t → i g → v o → n c → o s → e s → o k → h z → r y → r y → p f → t a → d	h → b j → l b → h f → t t → f c → e e → c i → l i → j m → n n → a u → a l → j q → d w → u y → v k → h v → y m → w p → b x → z f → l w → v	m → w j → l l → i r → f h → b n i → l l → j y → v o → e t → i b → h i → t e → c f → i t → l k → h v → w j → i w → a y → p z → x q → o	e → o f → l b → h e → a i → l c → r z → x t → l f → j t → i p → n a → o o → a s → n y → v l → i f → r o → e q → g j → l z → r c → i l → j	l → i s → a g → q c → e b → h n → m z → a e → a c → o k → h s → e z → e h → b k → b x → a r → f r → t z → r o → e u → n t → i i → l e → m	a → n u s b → h c → e o e → c o g s f → l t i g → s h → b k i → j l t j → i l l → j t f n → m u o → n p → m q → o r → f t s → g t → f u → n v → y w → v x → y v y → v z → x

Figure 11 Summarizing the work of five different researchers looking into misreading of lowercase letterforms. (Beier S. , 2009; Sanford, 1888; Bouma. 1971; Tinker, 1928; Geyer., 1977; Dockeray, 1910)

2.3.4 Typography for Student

Typography for students is an area that attracts the interests of legibility researchers, educators and designers, however, designers, educators and legibility researchers haven't reached any joint conclusion on a typeface for children (Bessemans, 2016). The views of the teachers are usually based on prejudice and habit (Raban, 1984). Designers generally intend to follow the views of customers, and scientific readability researchers often do not have a professional approach to building valid test material (Bessemans, 2016).



Figure 12 Flicks in typeface Sassoon Primary (Bessemans, 2016)..

Teachers usually suggested sans-serif typefaces rather than serif typefaces, because they believed that sans-serif are simpler looking than serif typefaces. According to the teachers, sans-serif character's forms easier for children to read than serif typeface, also grotesque has formal similarities with written characters for them. These teacher's views are based on tradition and on the force of habit (Garfield, 2010; McLean, 1980; Raban, 1984).

Teachers views on the sans-serif typeface have historical roots. According to the modernist typographers, sans-serif typeface represented fundamental of the type design, because it resembled the bare bones of the alphabet. The association with the skeletal letterforms can be attributed to the application of many interchangeable components (see fig. 13). Sans serif was seen as the modern letterforms excellence due to its simple letterforms (McLean, 1980; Christopher, 2007). Teachers have preferred sans-serif typefaces in reading books due to this simplicity and they presumed that sans-serif was more closely related to the letterforms which children learn to write with than were serif typefaces (Walker, *The Songs the Letters Sing: Typography and Children's Reading*, 2005).

Designers created alternative letterforms for both serif and sans-serif typefaces (with preferred handwritten characteristics in typefaces for beginner readers) in response to teachers' needs. These specially designed letterforms called "infant characters" which are directly related to children's handwriting were introduced around 1920 and became more popular around 1930 with Gill Sans (see fig.14) (Walker, *The Songs the Letters Sing: Typography and Children's Reading*, 2005). Teachers and educationalists concluded that using infant characters in early reading books is beneficial due to similar handwritten characters (Pohlen, 2010; Walker, *The Songs the Letters Sing: Typography and Children's Reading*, 2005). In addition, Sassoon (1993) cited that the infant characters are critical on the beginning readers, which shows us that recognition is the critical factor on early reading.



Figure 13 Interchangeable components. Adrian Frutiger, Eine Typografie (Solothurn: VogtSchild-Verlag, 1981)

agyll49l — agyll491

Figure 14 Infant characters Regular versions compared to the versions with infant characters. Gill Sans versus Gill Sans Schoolbook. (Bessemans, 2016)

The assumption about typeface for children was translated into the design of letterforms by introducing rounded terminal strokes, the addition of flicks, long ascenders and descenders, which are believed to aid the identification of word images. Designers and teachers' assumptions regarding typefaces for children were based on tradition and popularity (Bessemans, 2016). Specially designed typefaces for children with the reading-writing needs of beginner readers are Sassoon, designed by Rosemary Sassoon and Adrian Williams in the 1980s, Fabula, designed by Vincent Connare in 1999-2000, and Twinkl Sans, designed by TypeTogether in 2015 (published in 2016). Specifically aimed at children typefaces are FF Schulbuch by Just van Rossum (1991), Fiendstar by Nicholas Garner (2006) and FS Me by Fontsmith (2009).

Shep was the sheepdog, but he did not like sheep. He said they were silly and boring.	Shep was the sheepdog, but he did not like sheep. He said they were silly and boring.
---	---

*Figure 15 Sassoon Primary (left) and Fabula (right)
(Bessemans, 2016).*

The infant typefaces do not have the overall appearance of conventional typefaces for reading, which causes a doubt for infant typeface. Teachers advise to use sans serif typefaces because they reflect handwriting qualities, appear simpler, and are supposedly easier to read. But type designers are aware of the fact that sans serif typefaces are not the most legible, and that infant characters have a little or no benefit for the reading material (Bessemans, 2016). The legibility depends more on the characters being recognizable. The legibility of words, in fact, depends more on the characters being decipherable and recognizable (Tracy, 1986).

The emerging literature shows research often intuitively supports the views of the teachers, pedagogues and educational publishers, who are not aware of the importance of type design (Bessemans, 2016). But at the same time, few studies in which both design issues and practice were taken into account were inconclusive regarding the validity of the views of the teachers. There is no consensus about which visual features of the text are suitable for readability of fonts for beginners (Walker & Reynolds, 2003). Apart from a few exceptions (such as the studies by Walker¹²), Much of what we know about typefaces for children's reading is based on prejudices, habits, feelings and traditions rather than on

¹²Walker stated that established typefaces for children's reading should have generous ascenders, descenders and proportions making a clear distinction between characters that are sometimes confused.

typographic knowledge and other kinds of knowledge. Therefore, the multidisciplinary approach is necessary for gaining better knowledge about children typography (Bessemans, 2016).

2.4 Typography for Individuals with Autism

Autism and reading is a complex topic, and reading is essential for autism to learn abstract words and communication. There is no any typography study for autism, but there are some typography instructions for them. These instructions sometimes may be based on tradition and assumptions. Autism has a large scale and symptom, therefore, some instructions that created for people with disabilities have been using also on autism. These instructions have been including some typography knowledge such as point size, fonts, line spacing and space between characters.

2.4.1 Text Size and Color

Sarah Omar & Azman Bidin has study about text and multimedia effect on individuals with autism they suggested some important point for using text on screen.

"When pictures and texts were used together with autistic children, the size of the fonts needs to be between 10 pt. and 14 pt. On the other hand, the font size of 16 is essential when the words come alone with no accompanying pictures are used the size range of certain fonts between 12 pt. to 14 pt. Being good examples of rounded fonts which have enough space between characters, the appropriate font types can be Arial, Comic Sans, Verdana, Helvetica, Tahoma, or Trebuchet" (Omar & Bidin, 2015).

2.4.2 The Web Accessibility

Many individual with autism have sensor sensitivity. Sensor sensitivity effect differences affect behavior and can have a profound effect on a person's life. Sensor sensitivity can cause stress, anxiety, and possibly physical pain. This can result in withdrawal, challenging behavior or meltdown (more information; see National Autistic Society), Therefore design and enrolment are essential for autism. Web accessibility is one of for them.

The Web Accessibility Initiative (WAI) is an initiative of the The World Wide Web Consortium's W3C. WAI ensure strategies, standards, resources to make the web

accessible to people with disabilities, and autism is one of them. Web accessibility means that websites, tools, and technologies are designed and developed so that people with disabilities can use them. More specifically, people can: perceive, understand, navigate, and interact with the Web thanks to web design.

Accessibility website for autism provides visual and typographical alternatives to textual material such as font, point size, line spacing color of the text, and pictograms. Some websites using these materials for people with autism, such as network.autism.org.uk and autism.org.uk. Autism Europe uses Easy to read instructions, (comes from Europe Standards) to make their website Easy to Read by autism. Autism Europe uses a software to convert the web page for autism easy to read (you can see the website without convert in figure 17 and with convert version in figure 18).



Figure 16 Autism Europe Website (without easy to read version) (Autism Europe).



Figure 17 Autism Europe Website (easy to read version) (Autism Europe).

2.4.3 *Easy to Read Instruction*

All citizens of the European Union have a democratic right to participate in the social and economic life of the society in which they live (ILSMH European Association, 1998). Access to information about their society’s culture, literature, laws, local and national policies and ethos is fundamental to take part in mainstream life. The reading is the key to find knowledge, and whole European citizens should have access to the information. For this reason, UK Department of Health (2009) and Cornell University (1998) published two different guidelines that call easy to read. It was explained in the guidelines, how to prepare easy to read the document for the individuals with low IQ, learning disabilities and autism. The following guidelines have been recommended to improve legibility and OPEN BOOK (software & website) and Autism Europe (Website) benefited from the following information.

The main instructions in guidelines as follows;
•Use clear typefaces. A clear typeface is preferred, for example Arial, Helvetica or Times New Roman.
• Use a large body size. The size of the letterforms should not be too small then 14 points is the recommended minimum for people with visual impairments.
• Be careful about how you emphasize text. Do not use block capitals and italics in the text. Use bold weight or underlining for emphasis.

Table 2 Cornell University (1998)

The main rules in guidelines as follows;
Rule 10: Words go on the right.
Rule 11: Words must be written clearly – A clear typeface is preferred, for example Arial, Helvetica or Times New Roman.
Rule 12: Words must be large – a font size at least 14 points is good.

Table 3 UK Department of Health (2009)

The key features in the legibility of various text display options are summarized by White (2004), and according Janan & Wray (2012), these features can be useful for autism. The features are listed in the following table:

Text Display Characteristic	Legibility Features
Body size	<p>Optimal font size is between 10 pt. and 15 pt. small size becomes less legible. Compare the following:</p> <p>How easy is this to read? (10 pt.)</p> <p>How easy is this to read? (12 pt.)</p> <p>How easy is this to read? (18 pt.)</p>
Font weight	<p>Medium-weight fonts are the easiest to read. Bold fonts attract attention in comparison. Compare the following:</p> <p>How easy is this to read? (Arial Narrow)</p> <p>How easy is this to read? (Arial)</p> <p>How easy is this to read? (Arial Black)</p>
Font style	<p>Roman is easier to read than italic. Italic can be used to emphasize short blocks of text for greater attention. There has been debate about the merits of serif and sans-serif Typefaces.</p> <p><i>How easy is this to read? (Italic)</i></p> <p>How easy is this to read? (Sans-serif)</p> <p>How easy is this to read? (Serif)</p>
Line length	<p>Roughly 50 to 65 characters is an ideal measure. Anything significantly smaller or larger loses legibility.</p>
Letterspacing	<p>Most fonts do not need extra letter-spacing (leading) because it should be part of the font design. It is best to keep with the original design.</p>
Wordspacing	<p>The space between words should be large enough to indicate clearly that they are different words, but not so large as to lose their connection to each other. Compare the following:</p> <p>How easy is this to read? (single word spacing)</p> <p>How easy is this to read? (triple word spacing)</p>
Leading	<p>The vertical space between lines of type should increase as the length of the lines increases. The lack of white space between lines makes it difficult for the eye to track from one line to the next. Usually a line-height between 1.15 and 1.5 works well.</p>
Justified or Text alignment (justify left and right)	<p>Type that is alignment left with a soft right edge is the easiest to read. Full justification risks creating uneven spaces between words. Compare the following:</p> <p>These lines are flushed left and have an unjustified right edge. Their advantage is that they maintain the same distance between words throughout.</p>

	These lines are fully justified – that is, straight on both left and right sides. It will be apparent that the between-word spaces are not equal here, which can be reading harder.
Lowercase, all caps, small caps	Lowercase letterforms have more contrast in their strokes, making them easier to read. ALL CAPS should be reserved for display type. SMALL CAPS can be used for emphasis, but sparingly.
Contrast between type and background	Black text on a white background is the most legible. Everything else reduces legibility.

Table 4 (Janan & Wray, 2012)

2.5 Chapter Discussion

Yaneva (2016) cited in her PhD studies that exploration of the effects of font sizes, font styles, line spacing and background colors on autism may prove to be a valuable venue for future research. Previous studies have focused on reading comprehension problem of autism (Fernandes F.D.M, 2015), for this reason studies have not presented any specific information on character perception by individuals with autism in the reading. Consequently, the literature lacks to design a typeface for people with autism. Literature has showed that the reading pattern of autism is quite similar to the impaired reading pattern, which can overlap also people with learning disabilities and low IQ. It means that a typeface for individuals with autism can cover the needs of these massive group of people.

Chapter 3

Survey study

3.1 Procedure

After the literature review, we prepared a survey to get answers we didn't find in the literature. The survey was designed with experts opinion and help. These experts are Dolunay Özentürk (Special Education Teacher in reading education of child with autism) and Kudret Nurdağ (principle of special education school). The survey was prepared in Portuguese¹³, Turkish, German and Turkish languages, and shared on the social media group pages (Facebook) about the education of people with autism. These social media group pages are listed according to their languages in the table below.

English Language Group; United Kingdom, Australia, United States of Amerika
Autism Teachers Unite!
Autismus-Gruppe
Autism Spectrum Disorder, through my eyes Discussion Group
Special Education Teachers
Autism Support For Parents And Teachers UK
ASD Classroom Support (teachers only)
Autism Acceptance Group
AUTISM. From Awareness to Acceptance
German Language Group; Germany
Autismus-Gruppe
Autismus - einfach anders e.V.
Frühkindlicher Autismus (AS Autismus Spektrum)
Kinder mit Autismus
Autismus oder Tourette Syndrom oder beides

¹³ Despite the efforts that has been made to have participants in the survey, no feedback was received from Portugal and Brazil.

asperger autisten
Portuguese Language; Brazil, Portugal
AUTISMO DIARIO - BRASIL
Autismo, Ciência e Espiritualidade
Asperger e Autismo no Brasil - Grupo
Autismo no Brasil
Turkish Language; Turkey
Özel Eğitim Öğretmenleri
Otizm Haber
Otizm kardeşliği
Otizimli Aileler Öğretmenler
Özel eğitim öğretmenleri ve aileleri buluşturan platform
Otizm

Table 5 Social-media group pages

Apart from these groups, it was taken support to distribute the survey from the special education schools, foundations and experts in teaching reading to individuals with autism.

• Saniye Karagözoğlu Special Education School
• Anadolu Autism Foundation
• Lerzan Special Education Center
• Dolunay Özentürk – Special Education Teacher in reading education of child with autism.
• Kudret Nurdağ, principle of speial education school

Table 6 Contributors to the survey by sharing and participating in the survey.

The survey consists of 9 sections. The sections contain different combinations (Relationships) of questions, which can direct participants to the different section according to their answers. In this way, we eliminated the participants who have not a relationship with the education of individuals with autism, making the survey more productive. The survey was conducted via google forms, in this way, it was aimed to reach more people online.

3.1.1 Survey Sections

- **Section one:** The first part is the introduction of the survey. There is an explanation that describes why the survey was conducted, by whom and what was its purpose. In addition, it includes information and contact numbers of the person who prepared the survey. The participants have to write their e-mail in this section, otherwise, they would not participate in the survey.
- **Section two:** This section was created to eliminate participants who have no relationship with the education of autistic individuals. It was given five options in the question: Teacher of students with autism, Researchers of autism, Parents of kids with autism, no association with autism and others. Participants who marked Parents of kids with autism and no association with autism were excluded from the survey. This section was made to get answers from the experts in the education of individuals with autism.

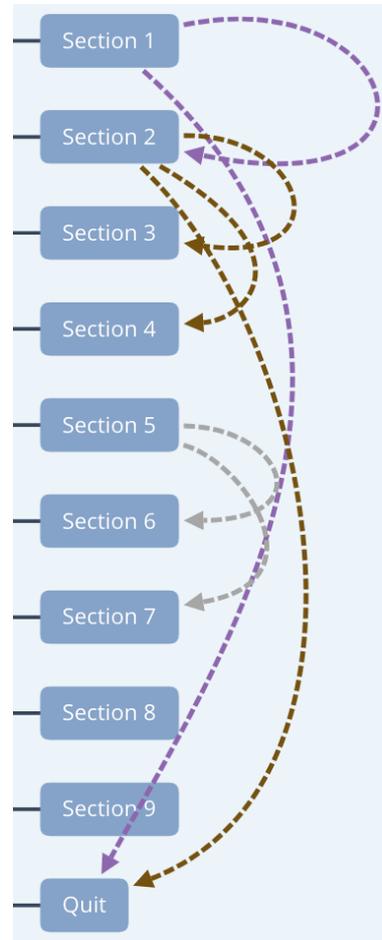


Figure 18 Survey sections

- **Section three:** This section was made for participants who chose the option 'other', to explain their relationship with autism.
- **Section four:** The questions from this section were intended to know whether individuals with autism have reading difficulties and learning to read difficulties.
- **Section five:** This part guided the participants to different questions according to their answers, as in Section one. The option 'it depends' led the participant to the sixth section, while the other options led the participant to Section seven. The option "it depends" allowed to get more detailed data about the reading status of the student with autism by sending the participant to Section six.
- **Section six:** Section six has a matrix question, it ensured that the participant gives a value to the options from one to seven.

- **Section seven:** Section seven has the same settings as section six.
- **Section eight and nine:** Section eight and nine are multiple-choice questions. It was asked to participants to show the pairs of letterforms which can cause the reading error on individuals with autism. The participants can choose more than one option or can pass the question without giving an answer.

The results of the survey will be given separately according to the language of the participants. The results from the German group are not sufficient because just two experts participated in the survey. Accordingly, the English and Turkish groups will be the basis for discussion and debate. The number of participants is listed in the table below.

English Group	30
Turkish group	45
German	18
The total number of participants in the survey	93

Table 7 Participants in the survey

We can separate in three the group of participants: no association (Parents and family members of children with autism), experts (researchers on autism, Teacher of students with autism) and Other. Who selected the option 'Other' is directed to 'section 3' for explaining their relationship with people with autism and accepted to participate in the survey. Some participants were removed from the survey in the 'Section 2', because they did not have enough knowledge about the education of autism. The list of participants who answered the question and the participants who don't, are listed below.

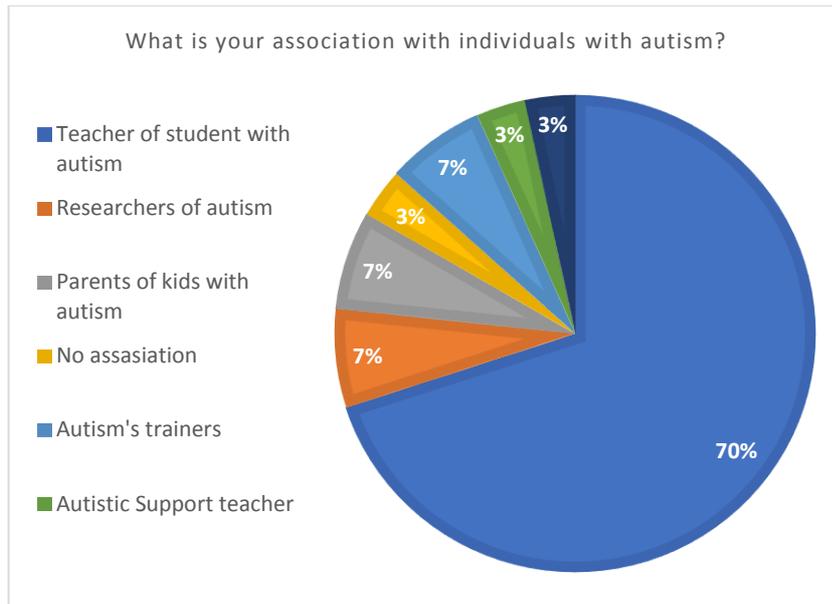
Groups	Experts	No Association	Other	Total accepted participants to the survey	Total
English Group	17	3	10	27	30
Turkish group	28	15	2	30	45
German	2	12	4	6	18
Total	47	30	16	63	93

Table 8 Group of participants comparison

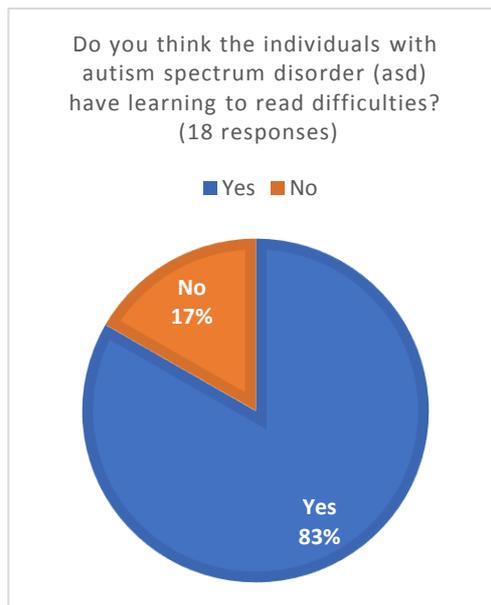
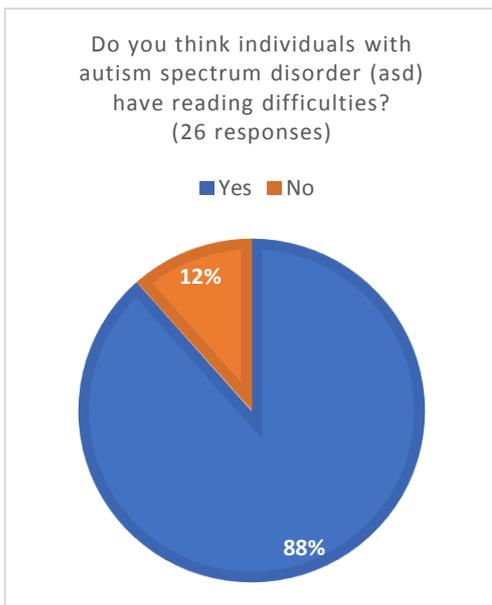
Total accepted participants answer was given at 3.3.1 and 3.3.2 in the bellow. Topic 3.3.1 presents the answer of the Participant with english language, and the Topic 3.3.2 presents the answer of the Turkish participants.

3.1.2 English Language Survey

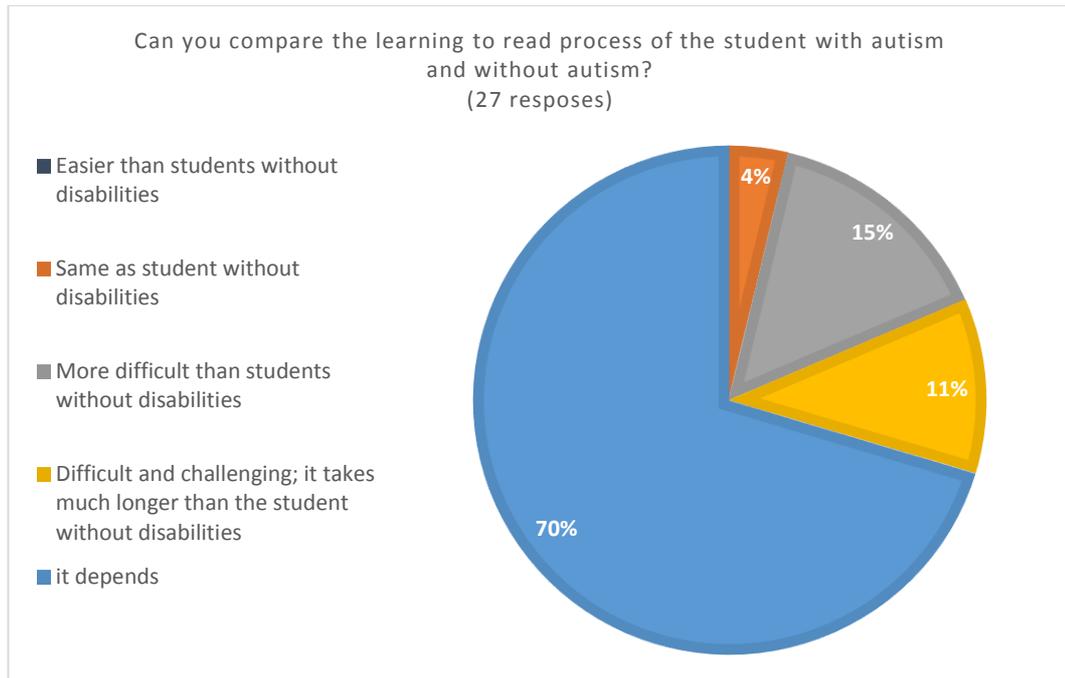
3.1.2.1 'Section 2-3'



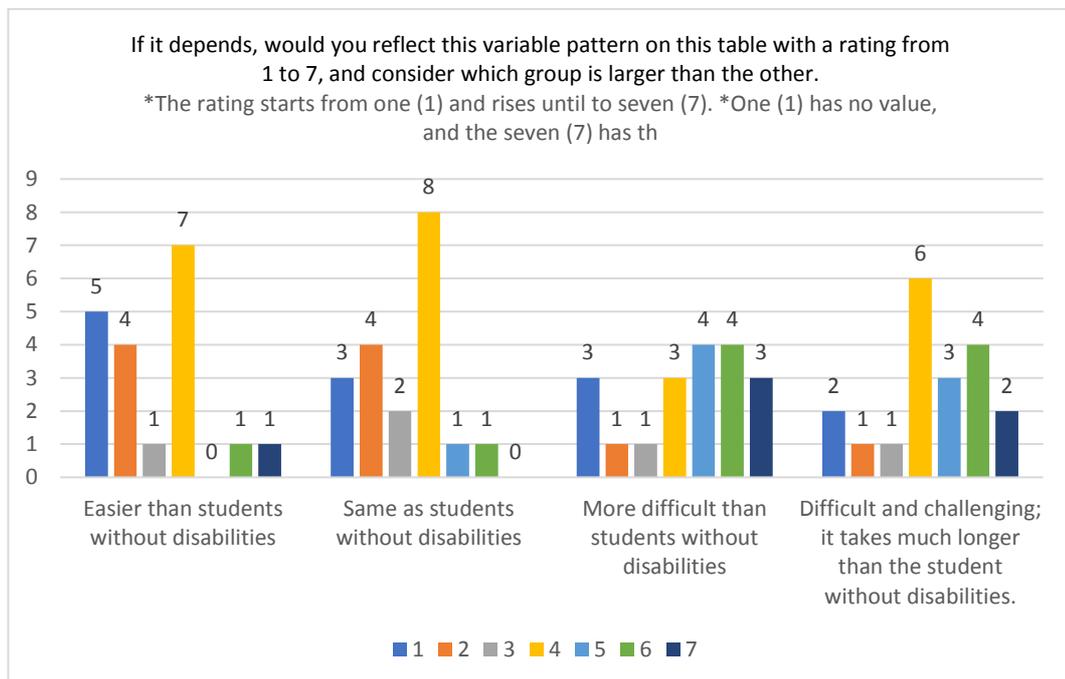
3.1.2.2 'Section 4'



3.1.2.3 'Section 5'



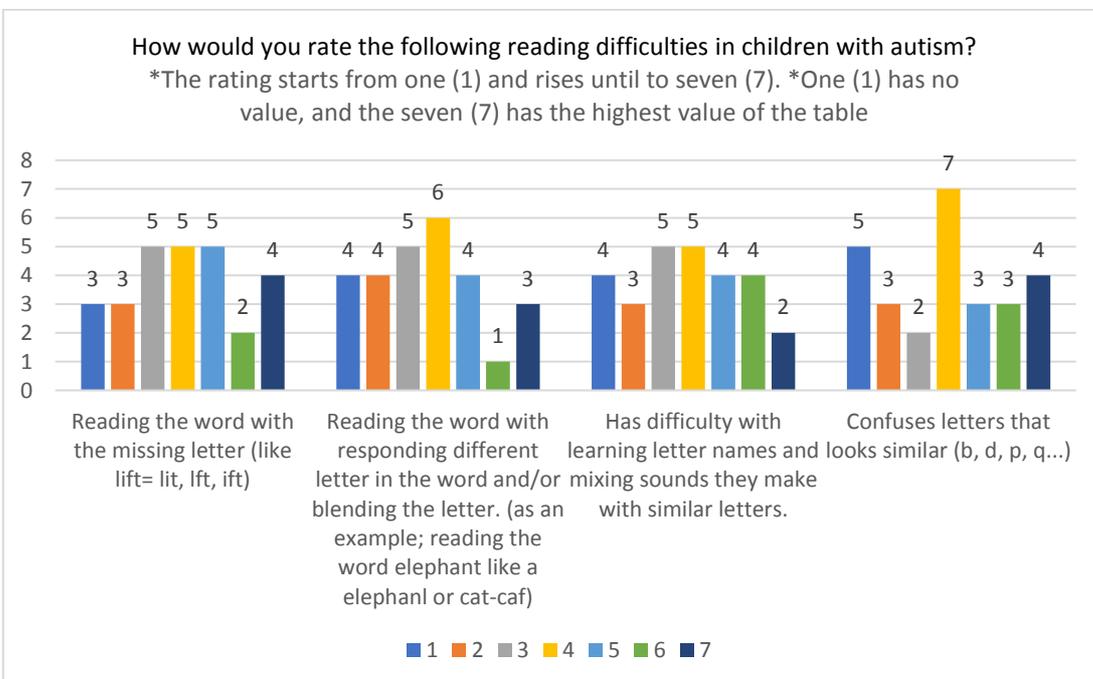
3.1.2.4 'Section 6'



In addition to the answer to the question, the participants added the following information in their own words.

Difficulty with comprehension of non-literal text.
Many of my students with ASD are non-verbal or limited verbal. They often do not have the listening skills and organization to read yet. I have not had a high functioning kid with AU. Mine all have ID (intellectual disability).
Everything is dependent on each individual student
With regular you're dealing with social issues that make it difficult but with ASD their brain sometimes has so much going on that it can be hard to retain the info. Especially those kids with narrow interests.
Students with ASD are different to students without ASD however, I have mainly worked with students who have high functioning ASD.
Question is very unclear. It all depends on the child w/ ASD and whether you are teaching comprehension or the mechanics of reading
Some children find the phonics based method of learning to read challenging.
Dependent upon whether or not the child with ASD also has a learning difficulty
Children with autism learn by whole word recognition...the find blending sounds very difficult

3.1.2.5 'Section 7'

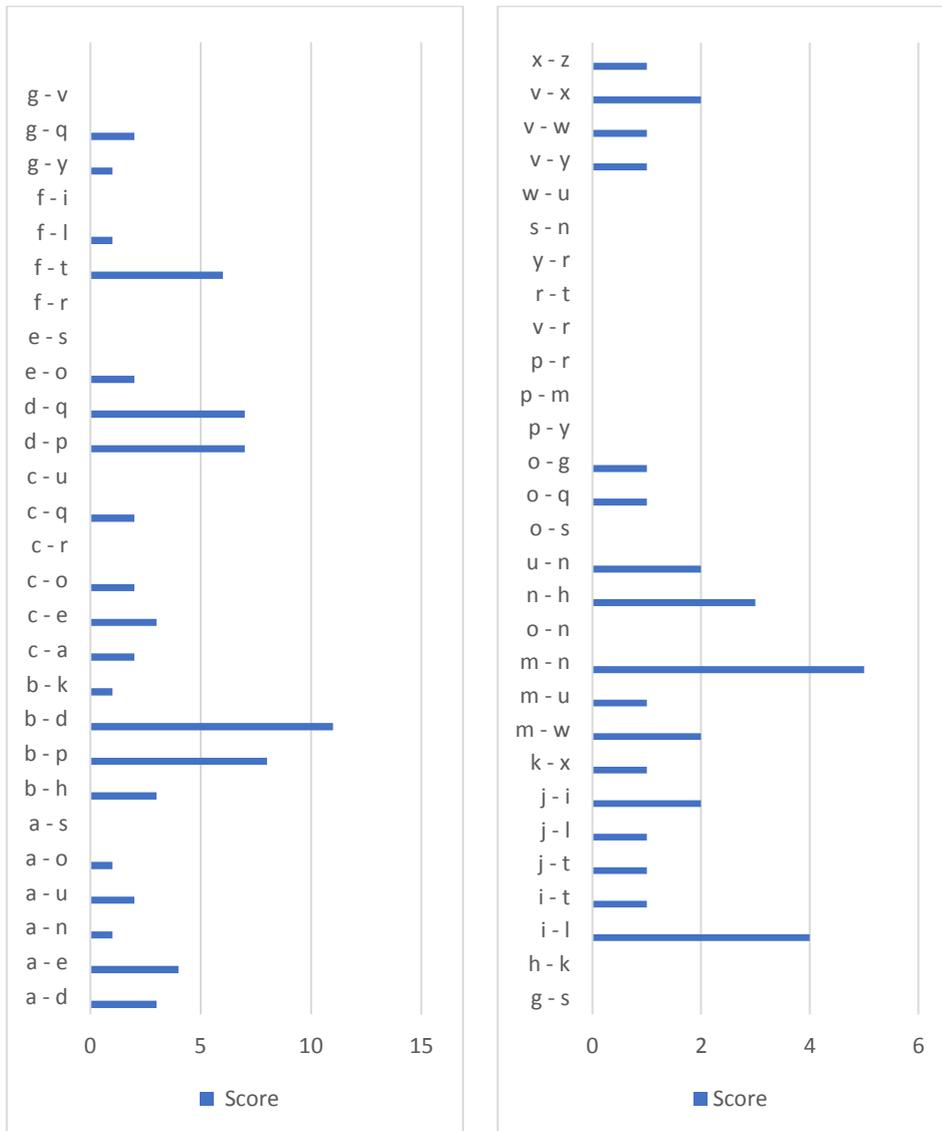


In addition to the answer to the question, the participants added the following information in their own words.

The problem usually relates with comprehension.
Many of mine do not talk.
Dependent on each individual student.
Some students with ASD do not have reading difficulties where some have. At times, students with ASD that have reading difficulties is a result of other learning difficulties such as dyslexia which is separate from their ASD diagnosis.
Again, this depends on the individual.
Students on the spectrum are very visual they do best when taught whole word instead of phonics and when words are associated with a picture. Therefore, nouns and verbs are easier to teach.
Again, dependent upon learning difficulties and speech problems.
Blending known sounds to decode phonetic words is difficult.
Blending letter sounds are most difficult. Students that I teach learn by whole word recognition.

3.1.2.6 'Section 8'

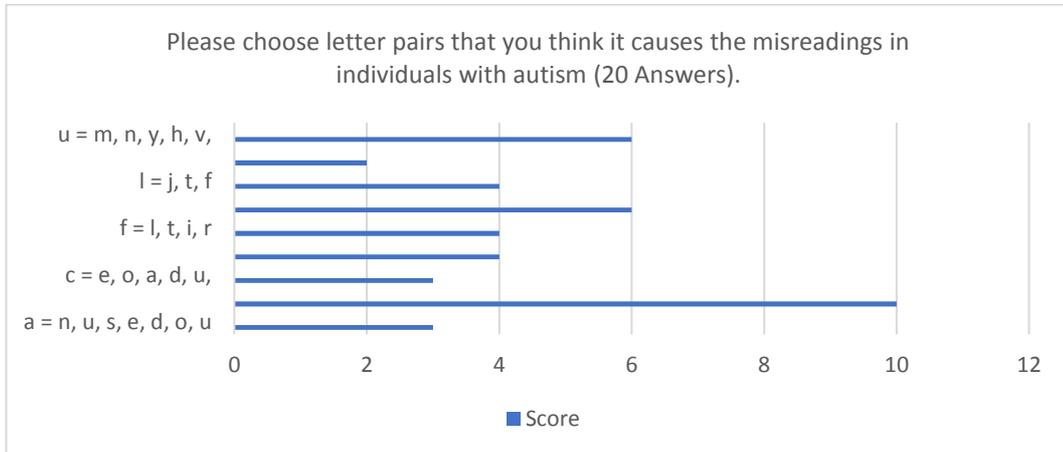
Please choose letter pairs that you think it causes the misreadings in individuals with autism (20 Answers).



In addition to the answer to the question, the participants added the following information in their own words.

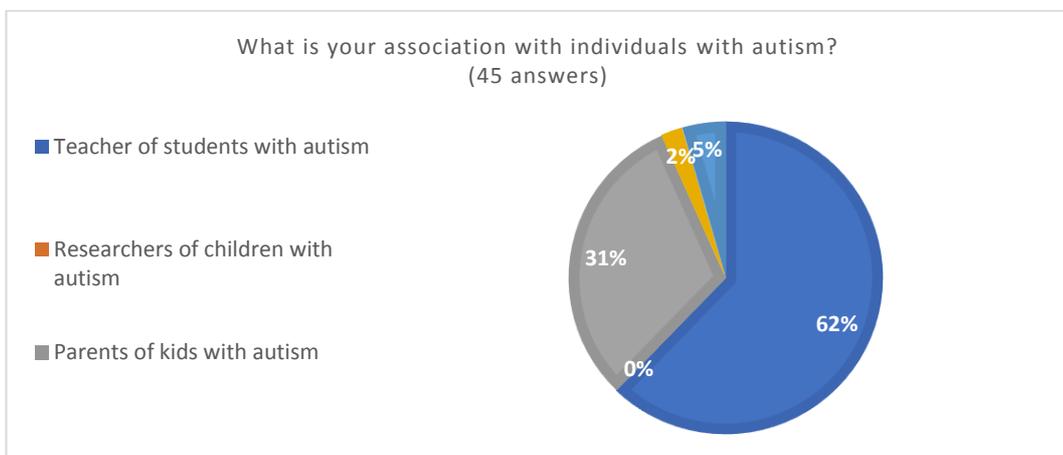
It depends on developmental needs of each students and their learning method

3.1.2.7 'Section 9'

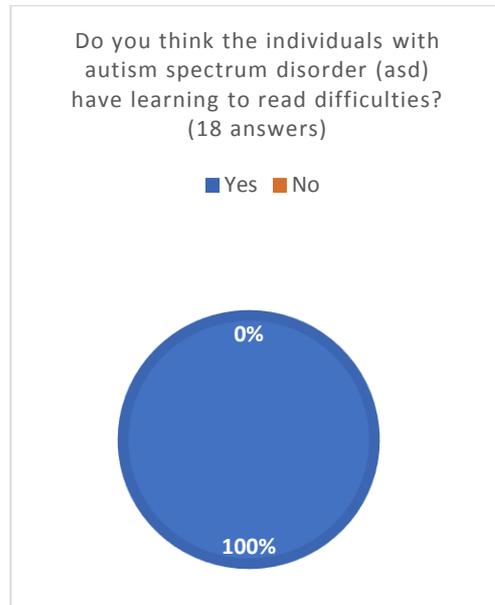
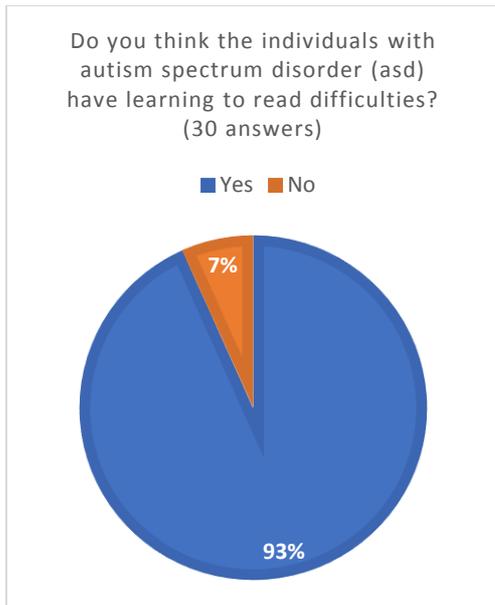


3.1.3 Turkish Survey

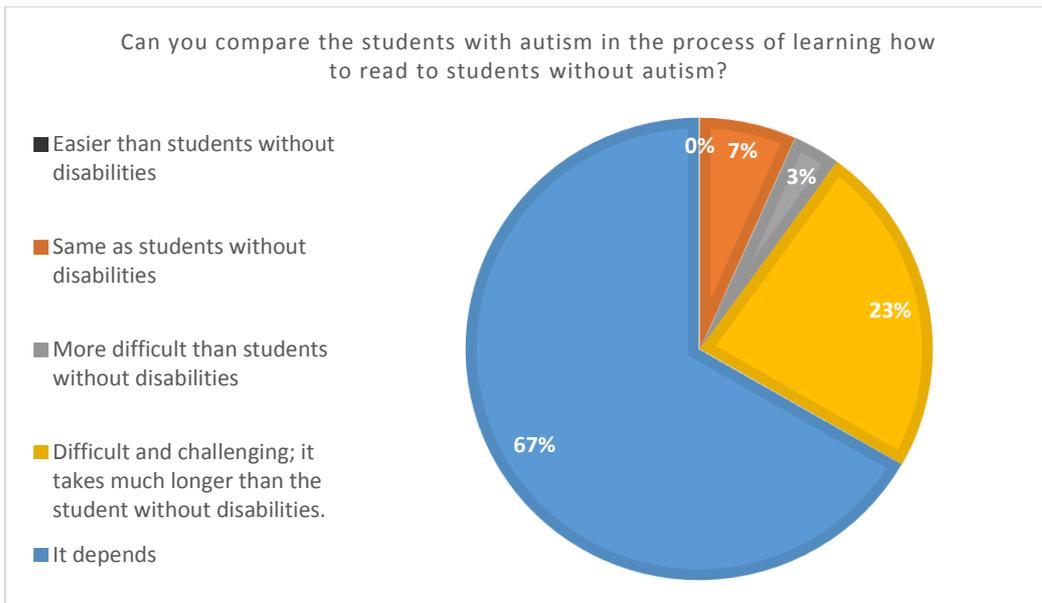
3.1.3.1 'Section 2-3'



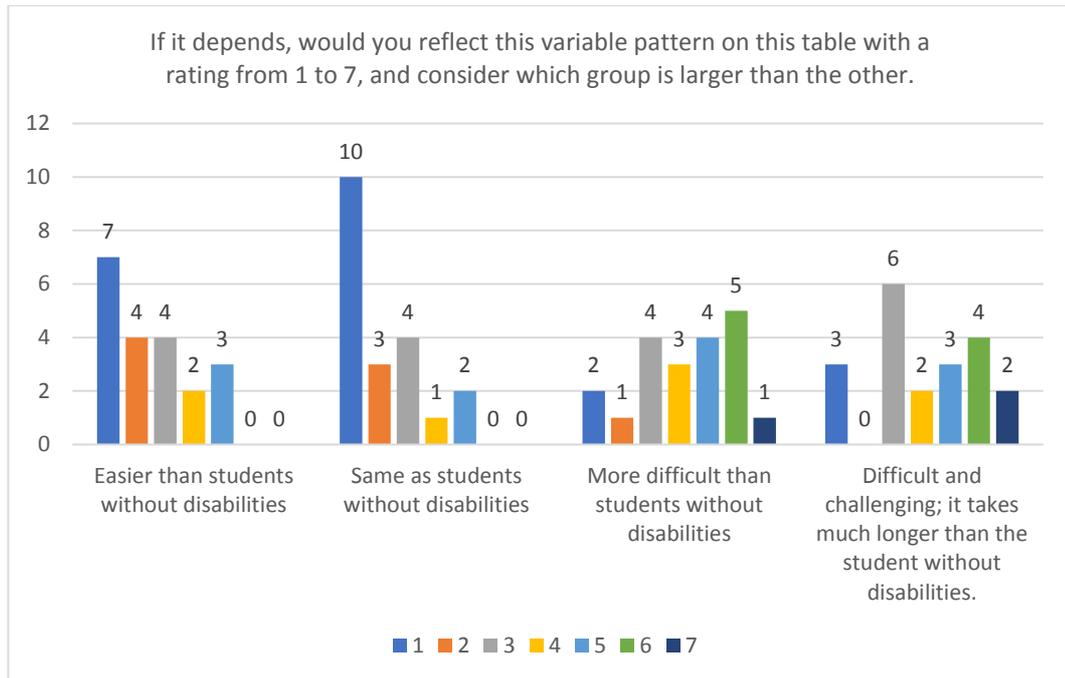
3.1.3.2 'Section 4'



3.1.3.3 'Section 5'



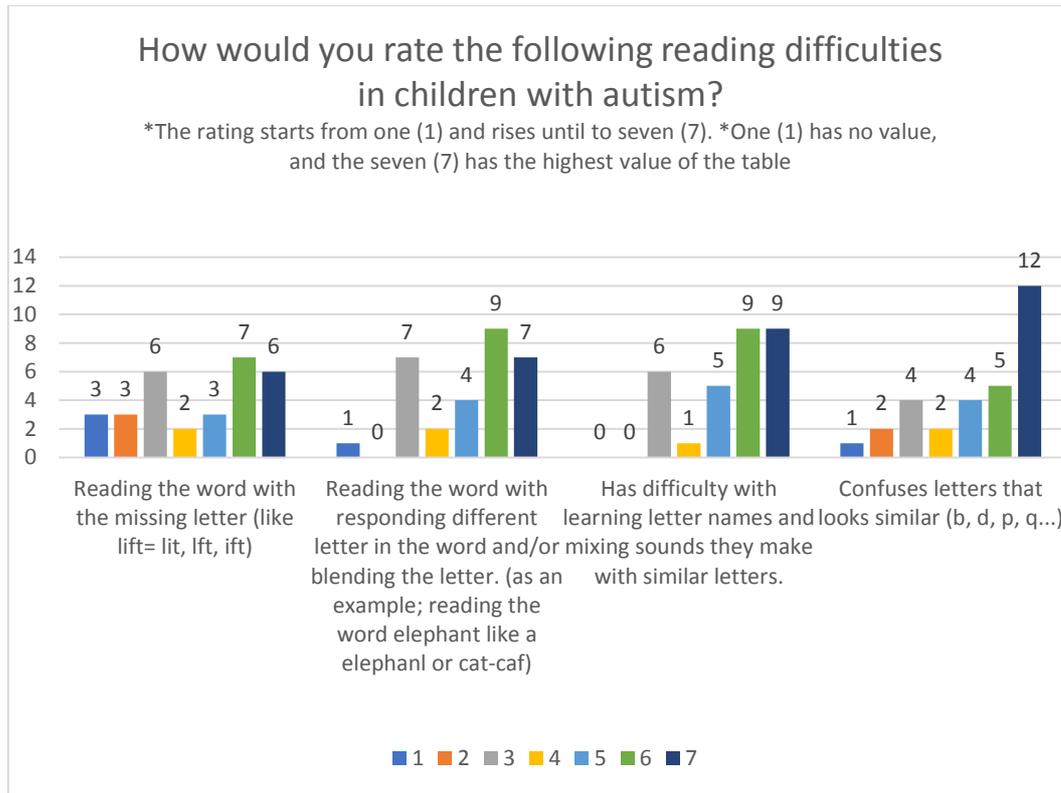
3.1.3.4 'Section 6'



In addition to the answer to the question, the participants added the following information in their own words.

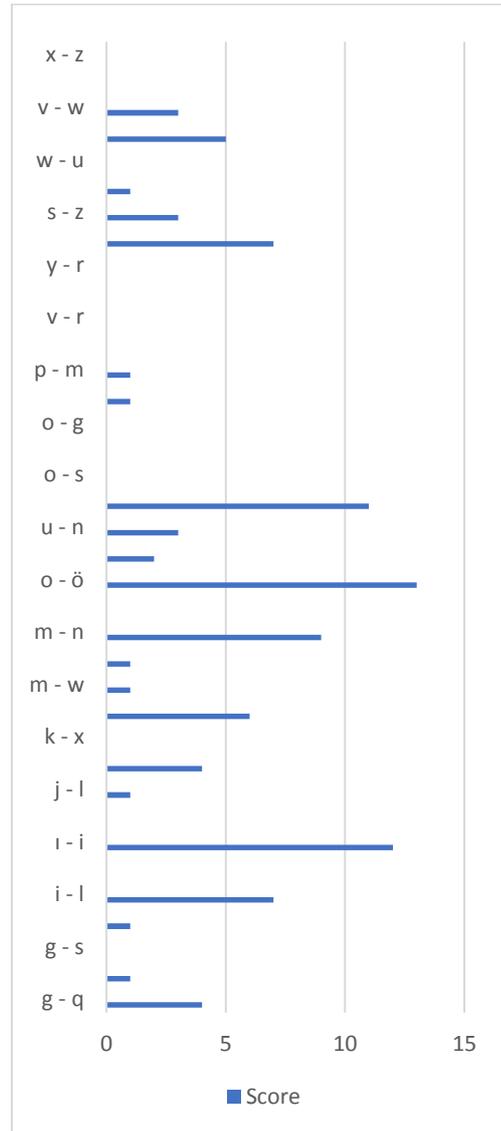
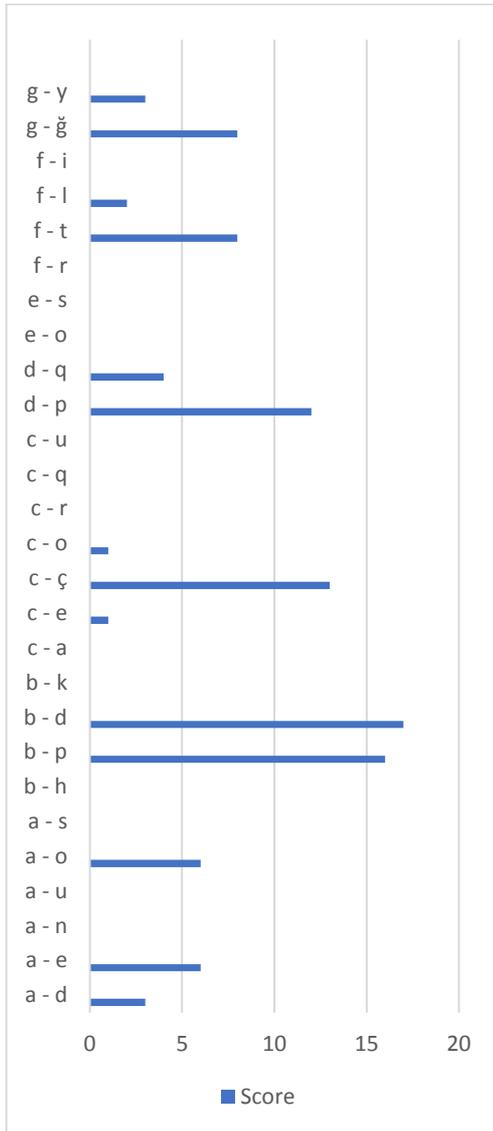
Because the visual completion and visual memory skills of students with autism are usually more, the skills of learning and memorizing reading, or analysis, are usually easier. The ability to read and understand together is more difficult than for children with normal development.
Attentional problem behaviors affect children's learning process.
Reading is learned but it may be a didactic reading for lack of emotion.
The learning process for individuals with autism varies according to the individual. The technique of teaching methods of literacy can also change.

1.1.1.1. 'Section 7'



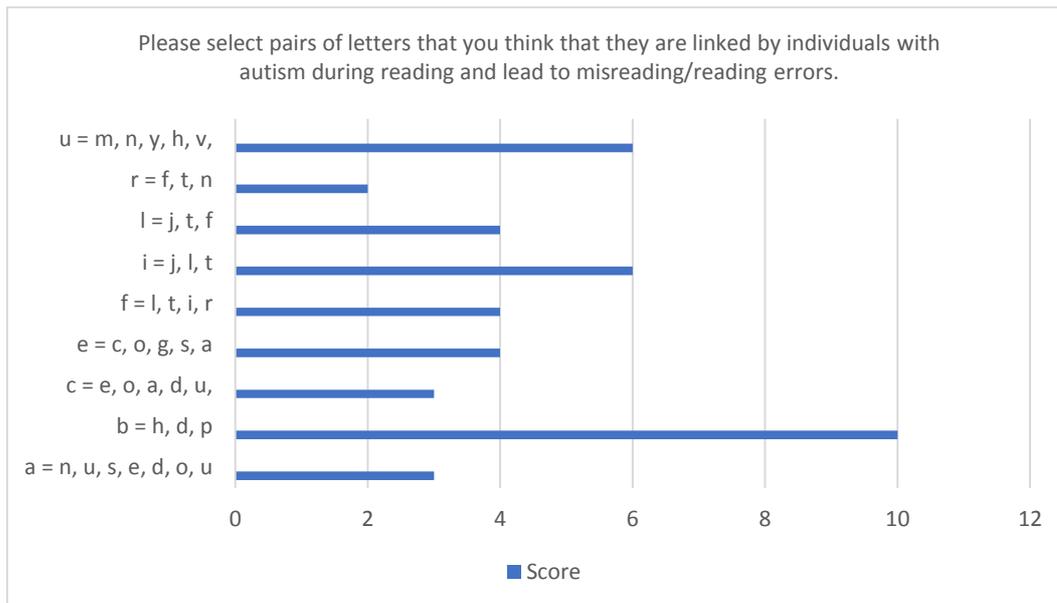
3.1.3.5 'Section 8'

Please choose letter pairs that you think it causes misreadings in individuals with autism.



It was asked to participant to add letter pairs that are not found on the table but lead to misreading and reading mistakes.

F v/ b m/ g ğ
O u, n m



3.2 Analysis and Discussion

3.2.1 Section 4

It was asked that in 'Section 4' 'Do you think the Autism spectrum disorder (ASD) have reading difficulties?' A total of 65 answers have been received from the Turkish and English groups. In the English group, 88% of subjects think that individuals with autism have reading difficulties and in Turkish group %93 of the participant think that individuals with autism have reading difficulties. Besides the results showed that autism has generally reading difficulties, the question is a general question, because there may be several reasons of reading difficulties such as reading comprehension or decoding problems.

It was asked that in **Section 4** "Do you think the Autism spectrum disorder (ASD) has the learn to read difficulties?". 83% of the English participants respond yes option, and 100% of the Turkish participants respond yes option. It is shows most of the consulted experts thinks the individuals with autism has learning to read difficulties.

It's known that individuals with autism may have learning difficulties and they need special education. Usually, they have reading comprehension problem. But the literature is emphasized that they are good decoders and can learn to read easily, but with poor comprehension. (Newman, et. al. 2007). This section used to learn what is the general thoughts of the experts about learning to read difficulties of people with autism. Because literature was disoriented by giving different conclusions.

Both question and answers are general, and does not allow us to gauge if there are problems of visual recognition of the letterforms. but at the same times, it is shown that there are 'reading difficulties' and 'difficulties in learning to read' in the autism population. this question results are enough to make new research on individuals with autism about reading.

3.2.2 Section 5

In 'Section 5', it was asked 'Can you compare the students with autism in the process of learning how to read to students without autism?', and totally 50 answers have received in this question both Turkish and English group. This question was asked to know the general knowledge about learning to read difficulties in autism because the information in the literature is insufficient to get a conclusion. In the literature, only Nation (2006) emphasized that the reading ability is variable among individuals with autism. The survey reiterates this information but at the same time, it shows that learning to read is not easy compared with students without autism, that it is a new data that contradicts this literature. except of the Nation (2006), general literature emphasizes that the reading pattern of individuals with autism is characterized with the hyperlexia reading profile. (Grigorenko, et. al.).

Section 5 is a very general question, and the answers are inadequate to arrive at a conclusion. For this reason, the 'It depends' option has been made, and 70% to 60% of the participants have marked this option. This option guided the participants to 'Section 6', and enable them to rate learning to read process of the individuals with autism in the autism population from small to large .

Options	Answers	Value
Easier than students without disabilities	0	0.00%
Same as student without disabilities	1	4.00%
More difficult than students without disabilities	4	15.00%
Difficult and challenging; it takes much longer than the student without disabilities	3	11.00%
it depends	19	70.00%

Table 9 English group survey Section 5

Options	Answers	Value
Easier than students without disabilities	0	0.00%
Same as student without disabilities	2	6.7%
More difficult than students without disabilities	1	3.3%
Difficult and challenging; it takes much longer than the student without disabilities	7	23.3%
It depends	20	66.7%

Table 10 Turkish group survey Section 5

The participants listed the learning status of individuals with autism respectively according to the students without autism in Section 5 English group. Based on the participants answers, experts think that students with autism have problems in learning to read comparing to students without autism.

Similar results were obtained from the Turkish group. However, it seems to be more consensual among experts in the Turkish group, the difficulties of learning to read. It may be thought that the difference in language is due to different letters in the alphabet.

The participants who marked the option it depends in section 5 were directed to Section 6, and the others to Section 7.

3.2.3 Section 6

It was asked that in **'Section 6' to reflect variable pattern with a rating from 1 to 7, and consider which group is larger than the other**. The question was asked to know about the process of learning to read of the student with autism, and to distinguish this population within groups. The results have made it possible to define the 'learning to read process' from small to large in the autism's population. These are available in the following table.

Options	1	2	3	4	5	6	7	Average
Easier than students without d.	26,32% 5	21,05% 4	5,26% 1	36,84% 7	0,00% 0	5,26% 1	5,26% 1	3
Same as students without d.	15,79% 3	21,05% 4	10,53% 2	42,11% 8	5,26% 1	5,26% 1	0,00% 0	3,16
More difficult than students without d.	15,79% 3	5,26% 1	5,26% 1	15,79% 3	21,05% 4	21,05% 4	15,79% 3	4,47
Difficult and challenging; it takes much longer than the student without d.	10,53% 2	5,26% 1	5,26% 1	31,59% 6	15,79% 3	21,05% 4	10,53% 2	4,42

Table 11 English group survey Section 6

Options	1	2	3	4	5	6	7	Average
Easier than students without d.	35,00% 7	20,00% 4	20,00% 4	10,00% 2	15,00% 3	0,00% 0	0,00% 0	2,5
Same as students without d.	50,00% 10	15,00% 3	20,00% 4	5,00% 1	10,00% 2	0,00% 0	0,00% 0	2,1
More difficult than students without d.	10,00% 2	5,00% 1	15,00% 3	20,00% 4	25,00% 5	21,05% 4	5,00% 1	4,25
Difficult and challenging; it takes much longer than the student without d.	5,00% 3	0,00% 0	30,00% 6	10,00% 2	15,00% 3	25,00% 5	10,00% 2	4,1

Table 12 Turkish group survey Section 6

Both table shows that individuals with autism has variable learning to read pattern. According to the participants answers, it's clear that people with autism can learning to read more difficult and sometimes challenging way than students without autism. It was asked to the participants reflect the autism population learning to read. If we sort the results from the largest to the smallest groups will be like: 'Difficult and challenging; it takes much

longer than the student without disabilities.' > "Difficult and challenging; it takes much longer than the student without disabilities.' > 'Same as students without Disabilities' > 'Easier than students without disabilities.'

It shows us that generally individuals with autism are not good readers, and at the same time have difficulty in learning to read. This demonstrates that there are individuals who have difficulties to learn to read within the autism population. The literature review didn't show the specific information about what can cause learning to read difficulty. Just the literature reported that there were conditions such as learning difficulty, IQ, and autism symptoms in the autism population (Åsberg & Sandberg, 2012). The results show that autism has difficulty in learning to read.

3.2.4 Section 7

Section 7' was designed to identify the reading difficulties in individuals with autism.

3.2.4.1 English Group

As a result of an interview that made with the experts, it has been learned that the students with autism may read the word with the missing letter in the word. Therefore this problem has been added in the question and this option took the highest value emerged in the table. It has been learned that in the Easy to Read document and interviews with experts; it is easier to read when there is sufficient space between the letterforms. Perhaps this problem can be corrected by opening the spaces between the letterforms. Further research on the subject is needed, but this input is valuable to identify possible factors of learning to read problems.

The second option shows the lowest rating between the options. The value of this option does not prove that the problem is characteristic with the individuals with autism, therefore, it must be investigated more clearly to know whether the characterize with the individuals with autism.

The third option has a value above the average, it may come from learning difficulty, it should be examined detail to know what cause of this problem.

The fourth option is a feature that is fully characterized by dyslexia. This problem, caused by the misperception of the letterforms, supports the idea of a new typeface for autism with a value above the average.

According to the results, it is obvious that individuals with autism are having reading difficulties even if it is not the high level. These problems are not mentioned in the literature, thanks to survey it has gained the literature. These problems need to be supported and examined in detail by future research. The results are contributed in response to one of the research questions. It has been found out that they may mix similar letterforms, and jump letterforms while reading a word (e.g. lift lit).

Options	1	2	3	4	5	6	7	Average
Reading the word with the missing letter.	11,11% 3	11,11% 3	18,52% 5	18,52% 5	18,52% 5	7,41% 2	14,81% 4	4,04
Reading the word with responding different letter in the word and/or blending the letter.	14,81% 4	14,82% 4	18,52% 5	22,22% 6	14,81% 4	3,70% 1	11,11% 3	3,63
Has difficulty with learning letter names and mixing sounds they make with similar letters.	14,81% 4	11,11% 3	18,52% 5	18,52% 5	14,81% 4	14,81% 4	7,41% 2	3,81
Confuses letters that looks similar (b, d, p, q...).	18,52% 5	11,11% 3	7,41% 2	25,93% 7	11,11% 3	11,11% 3	14,81% 4	3,92

Table 13 English group survey Section 7

3.2.4.2 Turkish Group

The Turkish and English group results are not consistent with each other. Even if the value of the first option in the English group has higher value than others, it is exactly the opposite in Turkish group. Turkish group has the second highest value in the second option as 5,1, but that is the lowest value in the English group as 3,63.

These inconsistencies do not have any scientific explanation, but it's clear Turkish group has more difficulty in reading. The highest values are the fourth option and third option, that is emphasizing Turkish students with autism may have strong difficulties in learning the letterforms, they can confuse the characters with similar shapes. Both tables

support the research main goal,i.e, that autistic students can benefit from a new typeface and we should consider these problems while creating a typeface for autistic students.

Options	1	2	3	4	5	6	7	Average
Reading the word with the missing letter.	10,00% 3	10,00% 3	20,00% 6	6,67% 2	10,00% 3	23,33% 7	20,00% 6	4,47
Reading the word with responding different letter in the word and/or blending the letter.	3,33% 1	0,00% 0	23,33% 7	6,67% 2	13,33% 4	30,00% 9	23,33% 7	5,1
Has difficulty with learning letter names and mixing sounds they make with similar letters.	0,00% 0	0,00% 0	20,00% 6	3,33% 1	16,67% 5	30,00% 9	30,00% 9	5,47
Confuses letters that looks similar.	3,33% 1	6,67% 2	13,33% 4	6,67% 2	13,33% 4	16,67% 5	40,00% 12	5,30

Table 14 Turkish group survey Section 7

3.2.5 Section 8

3.2.5.1 English Group

In English group survey, the letter-pair of ‘**b-d**’ took the highest value in section 8 with rate of 45.8% of participants. This problem is generally characterized with dyslexia. It is obvious that it is the most important pair to be edited in the typeface to be made for individuals with autism, and the differences between the two letterforms should be more. It may be a problem caused by the perception of these letterforms, for this reason, it needs to redesign and tested. The second highest value is the letter-pair of ‘**b-p**’ with 33.3% value and others are respectively ‘**d-p**’ ‘**d-q**’ 29.2%, ‘**f-t**’ 25%, ‘**m-n**’ 20.8%, ‘**i-l**’ ‘**a-e**’ 16.7%, ‘**e-c**’ ‘**a-d**’ ‘**b-h**’ ‘**n-h**’ 12.5%, ‘**a-u**’ ‘**c-a**’ ‘**c-u**’ ‘**c-o**’ ‘**c-q**’ ‘**e-o**’ ‘**g-q**’ ‘**j-l**’ ‘**m-w**’ ‘**u-n**’ ‘**v-x**’ %8.3. The common features of these letter-pairs that to have similar shapes with each other. The result of Section 8 emphasis that individuals with autism are having difficulties with these letterforms, also these letter-pairs may lead to misreading. These letterforms

should be designed again to better reading experience for the individuals with autism, and maybe a new typeface designed for autism can help to autism on this aspect.

3.2.5.2 *Turkish group*

The results of the Turkish group survey did not differ very much from the survey of the English group. The highest was the same letterform pair in both group. The 57.1% of participants choose the letter-pair of **b-p** and 60.7% of participants choose the letter-pair of **d-b**. It has been learned from the interviews with the experts that the individual with autism has problems with letterforms which looks like each other in the Turkish alphabet. These letterforms are **o-ö, ı-I, c-ç, u-ü, g-ğ, ş-s**, and the survey verifies this problem. This group of letters were valued at about 25% to 46.4%. The letter pair of **c-ç** and **o-ö** is the highest numbered letter group in this group. Experts say that this problem arises from the similarity of letterforms. However, it is clear that this problem should be examined in detail.

English Language	
Letter pairs	The rate of participants
b-d	45.8%
b-p	33.3%
d-p, d-q	29.2%
f-t	25%
m-n	20.8%
a-e, i-l	16.7%
e-c, a-d, b-h, n-h,	12.5%
a-u, c-a, c-u, c-o, c-q, e-o, g-q, j-l, m-w, u-n, v-x	%8.3

Table 15 English group survey section 8

Turkish Language	
Letter pairs	The rate of participants
b-d	60.7%
b-p	57.1%
c-ç, o-ö	46.4%
ı-i, d-p	42.9%
m-n	32.1%
f-t, g-ğ	28.6%
i-I, s-ş	25%
a-e, a-o, ı-I,	21.4%
v-y	17.9%
a-d, d-q, f-l, g-y, g-q, j-i, u-n, s-z, v-w	14.3% - 7.1%

Table 16 Turkish group survey section 8

We believe that is possible to add more differences on each of these letter can improve the legibility of these characters. As examples of these similarities, we have studied the letterform from 'o' and 'ö'. We have tried to show how we can simply increase the differences between them.

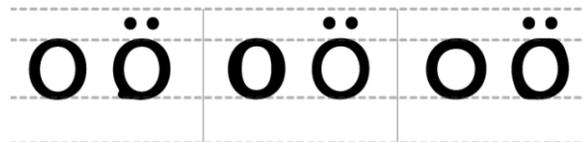


Figure 19 Example of character shape 'o' and 'ö'

It was not known in the literature whether the individual with autism had problems with the letterform from the alphabet. So, this lack of information hasn't been supporting the idea of designing a new typeface. The result of this question provided us with great knowledge to identify which letterforms can be problematic in their reading process but the question was based on studies on the relative legibility of the letterforms of normal people with maximum visual acuity, except extended Latin characters. Therefore this problem shouldn't identify based on individuals with autism.

3.2.6 Section 9

In section 9, the selected characters consist from the narrow, wide and rounded groups of letterforms. These letterforms are cited in the literature as the letters that may cause misreading (Beier S. , 2009; Sanford, 1888; Bouma. 1971; Tinker, 1928; Geyer, 1977; Dockeray, 1910). The results obtained were not different from the results in section 8, the highest value is the group **b = h, d, p** with %50 value, others like '**i = j, l, t**' and '**u = m, n, y, h, v**' have the highest second value in the survey. These results show us the character with similar shape may cause miss reading problems in individuals with autism. In addition, the results tell us which characters have to be redesigned to improve character identification and reading performance.

3.3 Chapter Discussion

This survey provided the information needed to design a typeface and this kind of information was not obtained from the literature. Based on this information, a typeface can be made in addition, we hope this information will inspire the further research on the subject. The results of the survey emphasized the following information.

Experts believe that individuals with autism have reading difficulties and learning to read difficulties.

According to experts, learning to read is more difficult for a student with autism than the student without autism, and sometimes it can be a long and challenging process.

Individuals with autism can have problems such as reading the letterforms incorrectly, mixing the shape of the letterforms with similar letterforms, difficulty learning letter names, and *letter jump*¹⁴.

Experts have shown the letters-pairs which can cause misreading by the student with autism.

In the survey, it was investigated individuals with autism and their problems in reading. But the literature shows that these problems may not be characterized by autism development disorders. This may be due to the normally delayed or impaired reading pattern. This knowledge led us to think this problem can cause of low IQ or learning disabilities. But it has to make new research to identify why. Considering this information,

¹⁴ Reading the word with a missing letter.

we can see that the typeface design can be used not only for individuals with autism but also for individuals with learning disabilities and low IQ. As a result, the typeface will be designed in a way to meet the needs of individuals with autism, learning difficulties and low IQ. This situation significantly increases the number of individuals who use typeface.

Chapter 4

Typeface Study

4.1 Method

The typeface was designed, according to the information obtained from the survey, interview with experts, literature review and from studies on the relative legibility of characters and typeface design. Firstly, characters were designed on paper and then moved vector-based computer software and were drawn again. The typeface family was designed by considering the information given in the survey output.

4.2 Study of character shape

4.2.1 Accessibility

Accessibility is a general term used to describe the degree to which a product, device, service, or environment is available to as many people as possible. Accessibility can be viewed as the “ability to access” and possible benefit of some system or entity. Accessibility is often used to focus on people with disabilities or special needs and their right of access to entities. This is about making things accessible to all people (whether they have a disability or not) (Wikipedia, 2019).

We made a typeface to be accessible for everybody. We supported our typeface with research that comes from special education teachers opinion on students with autism. The accessible font has customization support and several combinations according to individuals need in the reading, which makes our typeface accessible.

4.2.2 Similar Characters

In order to ensure the typeface harmony, typeface designers use the traits of the letterforms and design the other letterforms according to those traits. In this case, they can draw (**p**) based on from (**b**), they can design the (**V**) by using of the diagonals of the character (**A**). Many designers begin a typeface by drawing the lowercase (**n**). Because they

can create other characters (e.g. u, m, h) with reference to lowercase **n**. While all four letterforms are similar, they usually have subtle variations in curvature and width. Separating characters into their individual elements and properties allows a designer to treat the characters consistently across a font (Bruce & Nolen, 2009).

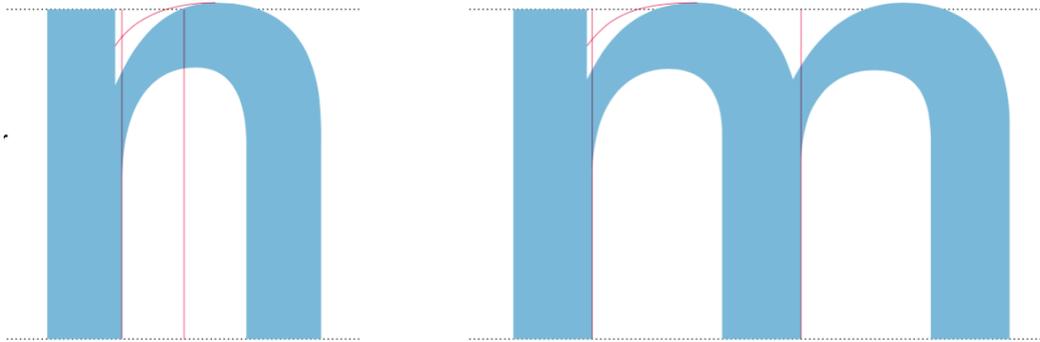


Figure 20 Letter traits (Bruce & Nolen, 2009, s. p.101)

Designing characters according to this grouping provides harmony to a typeface because the letterforms are designed in accordance with the shapes obtained from other glyphs, which helps to ensure typeface harmony. As can be seen from the results of our research, similar letters can lead to misreading. Therefore, a different strategy was used in Accessible Font. Besides using the same traits have harmony in design, different traits have been added in the versions (Regular v.2, v.3, v.4, v.5 and sets). These differences in the typeface were made to provide the individual's requirements in the reading. Thanks to this different approach, different characters designs have emerged to address different needs.

4.2.3 Design for Different Individuals Needs

According to the special education and experts opinions, we can know the letter pairs that individuals with autism may have misreading. But whole individuals with autism do not have the same problem. This is just a subgroup in the autism population. According to these results, we need to make a font that is accessible to everyone and can address different needs. In other words, the design should not disturb the reader, it should be compatible and easy to read, but at the same time, it should be able to emphasize the places of the character and to be distinctive from the similar shapes. To meet these requirements, 5 fonts and at least one set for each font have been designed. These five versions and sets ensure to meet individuals need in the reading process. It could use these five different

versions in the stylistic sets, but it wasn't used because of the special education teachers don't know use and apply open type features and also the software which they use to teach can't work with this kind of technology. Therefore five different fonts and at least one set for each font was used in the typeface family.

1.1.1. *Extended Characters*

In the Latin script, there are a lot of characters, which are separated by groups according to their feature as; Basic Latin, Latin-1 Supplement, Latin Extended-A, Latin Extended-B, Latin Extended Additional, Additional Latin Extended. In Turkish survey study, it was seen that Latin extended characters in the Turkish alphabet can cause misreading by mixing with basic Latin characters. As you can see in the Turkish script the Dotted 'İi' and dotless 'Iı' are separate letters in the Turkish language. We try to reduce the similarities between these group of characters by using serifs and sets in Regular v.2, Regular v.3 and Regular v.4.

A a	B b	C c	Ç ç	D d	E e	F f	G g	Ğ ğ	H h
a	be	ce	çe	de	e	fe	ge	yumuşak ge	he
[a]	[b]	[ɕ]	[tʃ]	[d]	[e]	[f]	[g/ʒ]	[ø ^ɟ]	[h]
I ı	İ i	J j	K k	L l	M m	N n	O o	Ö ö	P p
ı	i	je	ke	le	me	ne	o	ö	pe
[ɯ]	[i]	[ʒ]	[k/c]	[l]	[m]	[n]	[o]	[ø]	[p]
R r	S s	Ş ş	T t	U u	Ü ü	V v	Y y	Z z	
re	se	şe	te	u	ü	ve	ye	ze	
[r]	[s]	[ʃ]	[t]	[u]	[y]	[v/v]	[j]	[z]	

Table 17 Turkish alphabeth (LingvoSoft Online)

4.3 Accessible Font

Accessible typeface family was created based on the practices of the educators, typeface designers and researchers in the fields of psychology. The aim of the typeface study is to find solutions to the problems of the individuals who have difficulties in reading and the process of learning to read.

The accessible font was designed with a high x-height, different glyph combinations and reducing similarities between letterforms. The Accessible stand out with extended characters that support almost 200 Latin-based languages, covering math symbols, punctuation, and currencies.

Accessible font family is a simple and harmonious appearance as well as it offers great customization support to the pedagogues with differences in letterform design and stylistic combinations. As a result, a typeface is appeared to meet the individual requirements in which the teachers can change the character design according to students needs. This makes the Accessible font accessible for everyone.

The accessible font family consist of 5 fonts and each font has at least one stylish alternative. These fonts contain different glyphs combination and forms that ensure us to address different individuals needs in the reading performance.

4.3.1 Character Design of Regular v.1

In Accessible Font Regular v.1, the elements that disturb the reader are avoided and a neutral form was tried to be obtained. The aim was to reveal a font using only the factors affecting legibility. These factors are x-height, counters and terminals. It can see the structure and feature of the v.1 font is available below.

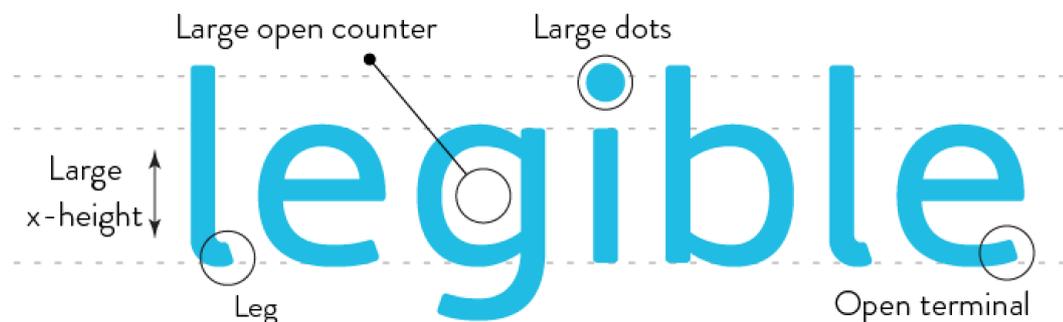


Figure 21 Accessible font designed with a high x-height metric, to be more legible. Accessible font metrics are: Ascender: 1505 Cap Height: 1434 x-Height: 1024 Descender: -410 (Units).

4.3.2 Accessible Font Regular v.2

The Regular v.2 font was designed especially for individuals who have difficulties in distinguishing letterforms between basic Latin and extended characters. Serif features were applied on extended letterforms so that extended letterforms were separated from the basic Latin characters as a different shape. This hybrid version was developed to help the individuals who learn reading with letter-based learning system but, it can use in the *word-based learning system*¹⁵ to identify better the characters in the word. The letterforms ‘o’ and ‘ö’ contain different forms order to have distinctive shape. The teacher can choose the set 1 option and convert the serif character to sans

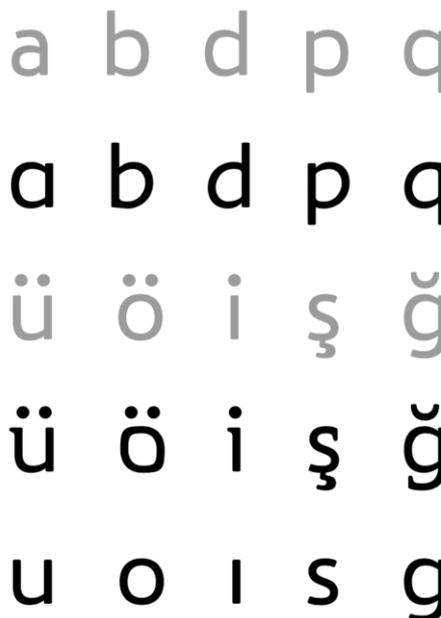


Figure 22 The characters with black color belong the Regular v.2 characters with grey color belong to the Regular v.1

serif so that only the letterforms of ‘a, b, d, p, q, f’ stays as different letterforms from v.1 (see fig.22). Set 2 provides to swap the serif feature on the extended characters to basic Latin characters (see fig.23). In this way, basic characters will have serif but extended characters will not contain the serif feature.

Basic Latin	ö	o	ü	u	i	l
Stylistic Alternates ss.01	ö	o	ü	u	i	l
Stylistic Alternates ss.01	ö	o	ü	u	i	l

Figure 23 Font sets and character features of Regular v.2

¹⁵ Word-based learning system is not based on the random word memorization. A word study program is a cohesive approach that addresses word recognition, vocabulary, and phonics as well as spelling (Zutell, 1992).

It was suggested to use clear typefaces like Arial Helvetica or Times new roman in the easy to read guide. You can see the differences between Regular v.2 Helvetica and Arial (see fig. 24).

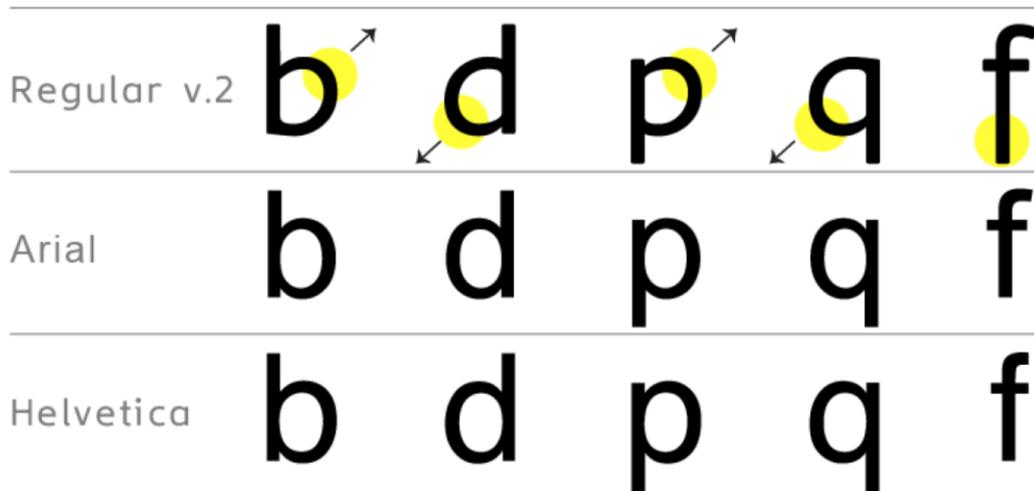


Figure 24 Differences between Arial, Helvetica and Regular v.2

4.3.3 Accessible Font Regular v.3

The Regular v.3 typeface was designed specifically for individuals who have difficulty in distinguishing similar letterforms. In Regular v.3 font, the main purpose of the design was to distinguish the similar glyphs, to avoid the distractive elements will disturb the typeface balance and harmony in the typeface family. It has been tried to reduce the similarities by adding serif features and different character shapes on similar shapes (like b, d, p, q.). In addition to these features, V.3 extended letterforms have serif features from V.2 and are coded as set 1. So teachers can combine features of Regular v.2 with Regular v.3. If the teachers wants to swap the serif between basic Latin and extended version, they can use set 2.

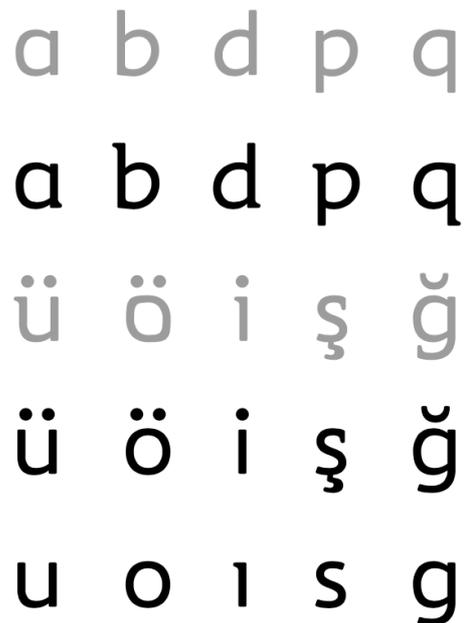


Figure 25 The characters with black color belong the Regular v.3 characters with grey color belong to the Regular v.2

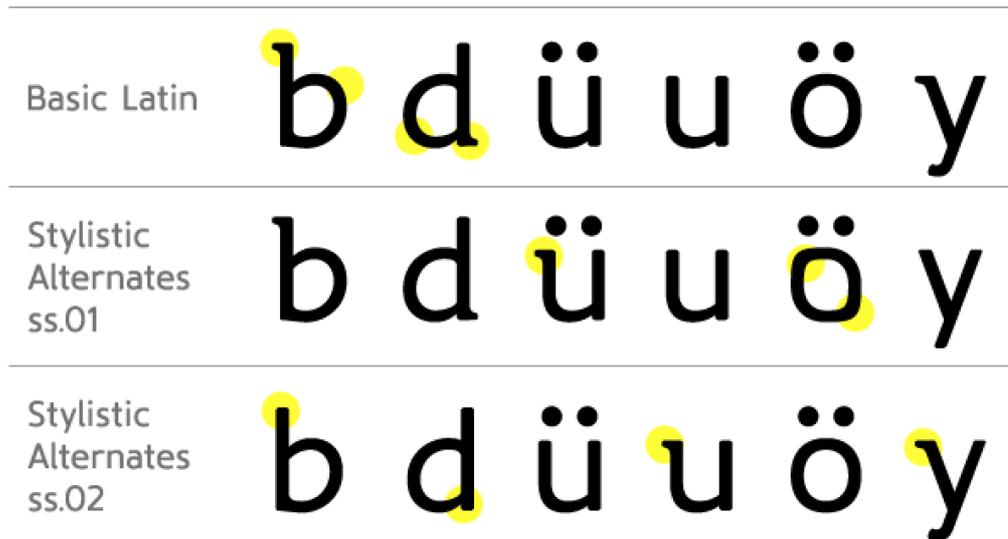


Figure 26 Regular v.3 typeface feature.

In v.3, it was created different terminals to better distinguish narrow characters. As shown in the examples, a stem with a different terminal was made to differentiate between lowercase 'l' and capital 'I' and serifs were added to lowercase j and t. It is thought that these differences may prevent some misreadings or even *blending a letterform*¹⁶ with others.

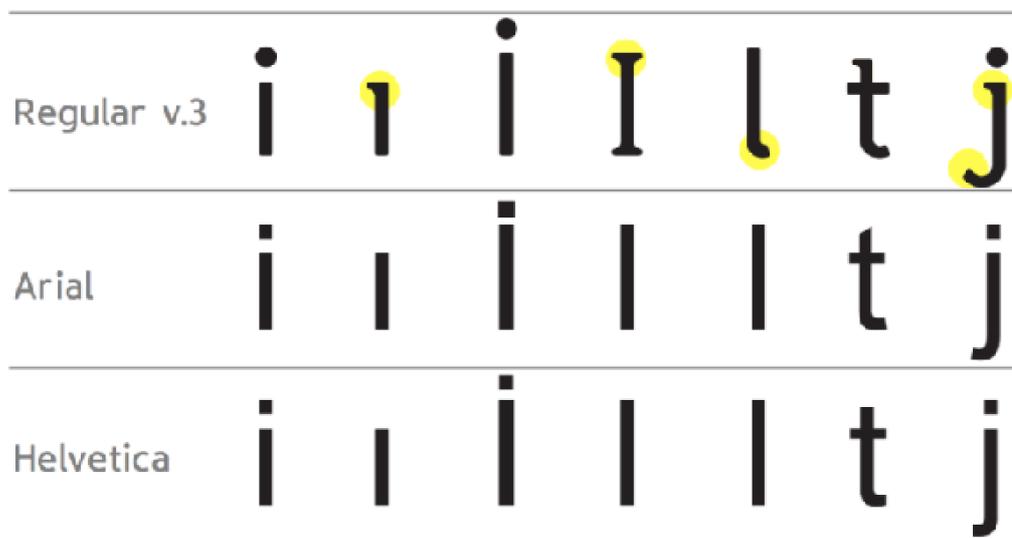


Figure 27 Differences of the narrow letterforms between Arial, Helvetica and Regular v.3

¹⁶ Nevertheless, the letterform blending may be due to other factors involving auditory deficit, hyperacusis problems of phonation or phonological processing.

Besides this feature, it was tried to catch a balance between the 'I' dotaccent (İ) and the capital version of the 'i' (see fig.27), because in Turkish alphabet, both letterforms are a separate letterform pair. In wide characters, we tried to reduce similarities with adding serifs to change the shapes without breaking the harmony (see fig.28).

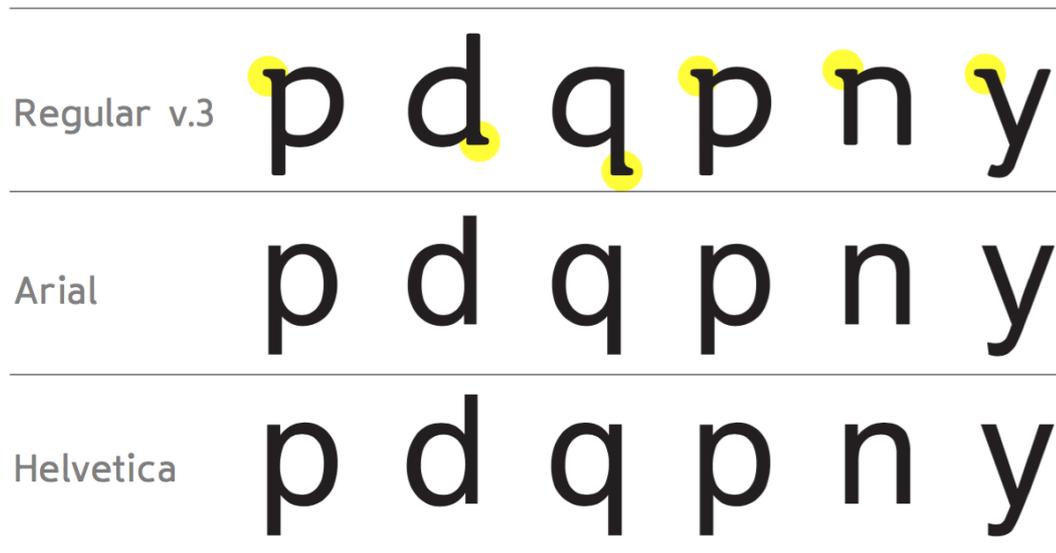


Figure 28 Differences of the shapes between Arial, Helvetica and Regular v.3

The experts showed that following pairs of letterforms generally mix with each other by individuals with autism. To avoid these misreadings, changes that made on characters are listed below. These changes can compare with Helvetica typeface to understand differences between the characters.

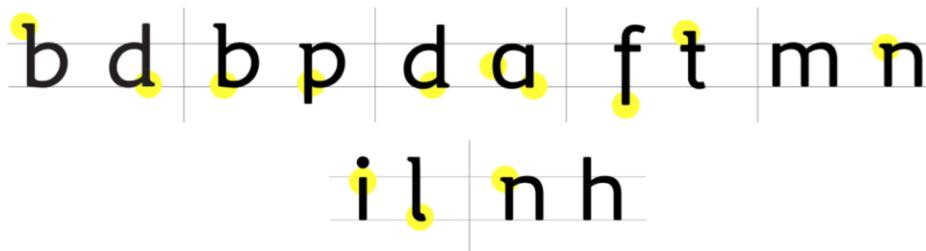


Figure 29 Differences between the similar letterforms of the Regular v.3

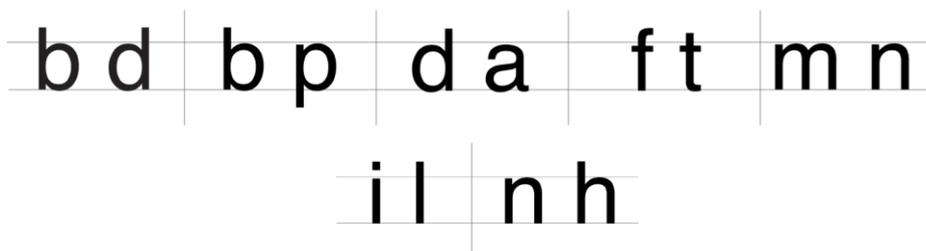


Figure 30 Differences between the similar letterforms of the Helvetica

4.3.4 Accessible Font Regular v.4

It was followed an approach to reduce the harmony between the characters and its similarities as much as possible while designing the regular v.4 font. The main feature of v.4 is that there are more elements that can disturb the reader than v.3. It is a version thought to give greater autonomy to the identification of the characters (to the legibility) in detriment of the readability. On this design, while some extended Latin characters have serifs, some characters have no serifs. So, in the design of v.2, all the extended Latin characters has serifs, while in v.4 only some characters (s-ş,g-ğ,c-ç,i-ı,ü-u,o-ö) has serifs. These some characters are letterform pairs obtained from the results of the Turkish survey, which can lead to reading errors.

In v.4 font, the characters 'a', 'b', 'e', 'h', 'n', and 'p' were designed in a different shape from the v.3. In this way, care was taken to increase the differences between the letterforms compared to v.3. Below, you can see differences between the versions.

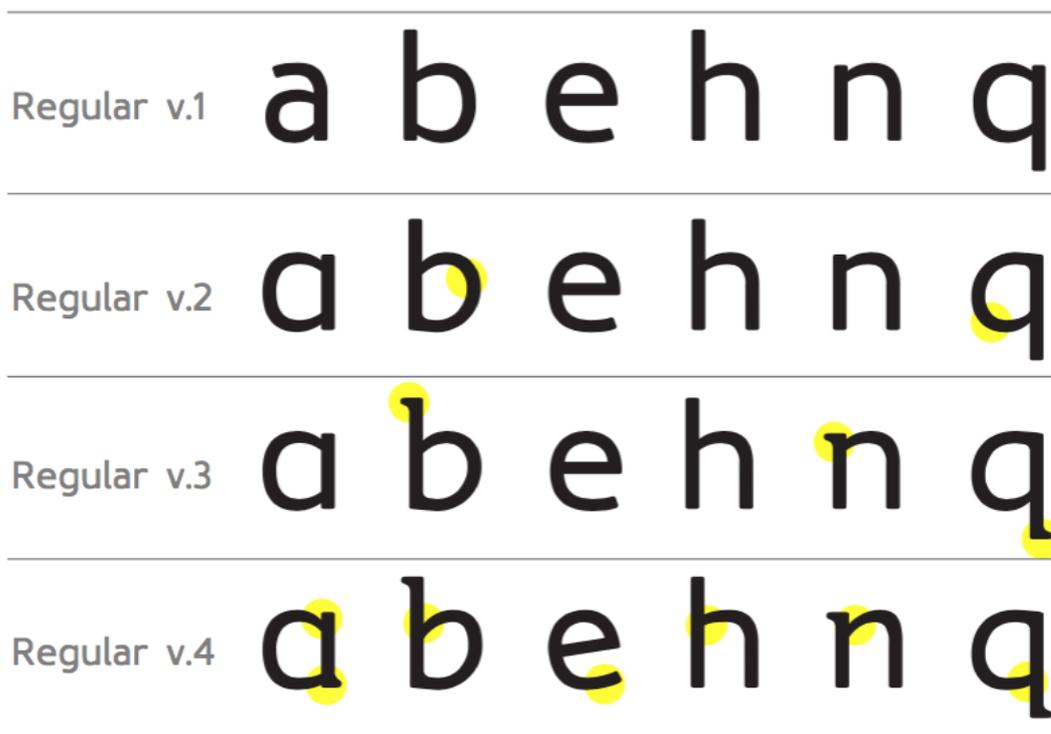


Figure 31 Development of the versions from Regular v.1 to Regular v.4.

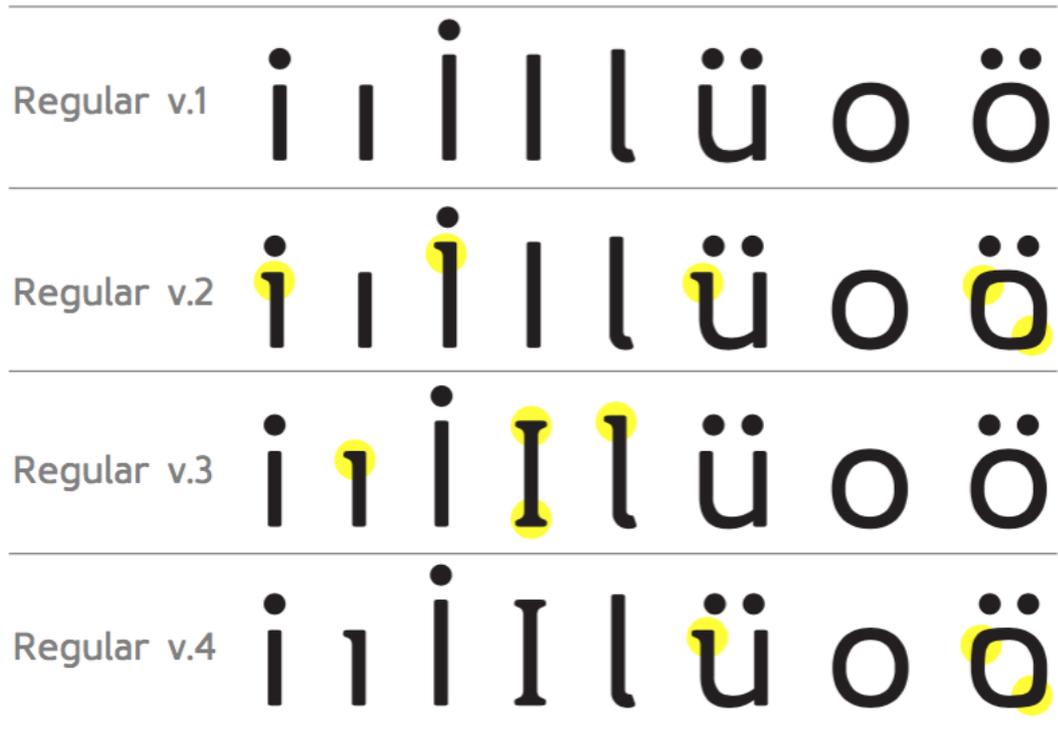


Figure 32 Differences of the similar letterform characters from v.1 to v.4

Below, it is possible to see the changes made to separate the letterforms pairs which are similar. The yellow colored shapes indicate the distinctive stimuli on the characters.

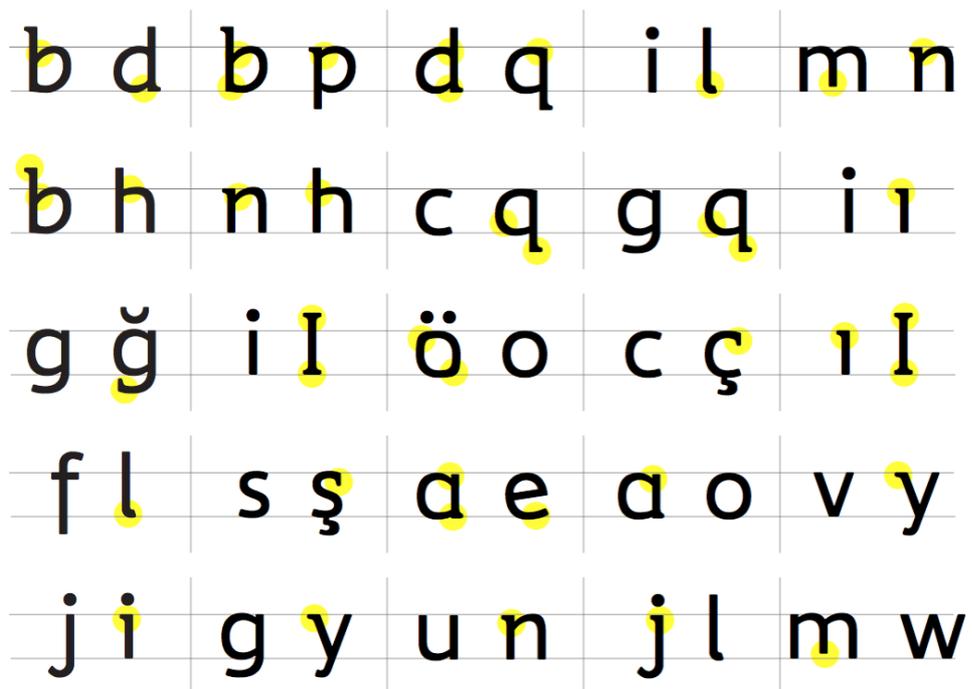


Figure 33 Differences of the similar letterform form of Regular v.4

4.3.5 Accessible Font Regular v.5

Regular v.5 is a hybrid font. The character structure of v.5 have taken from v.1 and add some serif feature to make whole characters hybrid. The v.2, v.3 and v.4 fonts were created with the combinations of v.1 and v.5. The v.5 and v.1 fonts are clear fonts, it can be used in the long paragraph. In the following table, you can see the basic Latin characters of the Regular v.5.

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z

4.4 Chapter Discussion

The accessible font was developed according to the results of interviews and survey study that made with teachers. However, this typeface should be seen as a test model for educators to prevent reading errors and teach the letters more easily on individuals with autism and learning disabilities.

It would not be right to make certain judgments about its effectiveness without testing the accessible font. Individuals who are taking special education may have individual needs in education, therefore teachers have many educational materials and various educational interventions to make their education effective. We are hoping that the accessible font to be one of these educational materials in reading education, thanks to customizations options of the typeface with five different version and stylistic sets.

4.5 CONCLUSIONS

The information taken from the survey showed that it is possible to create a new typeface for the individuals with autism who have misreading problems, or difficulties learning to read. According to information from the results of the investigation, experts in the field of autism education identified the letterforms which are usually misread by the student with autism. A new typeface was created in order to improve the legibility of the identified glyphs. According to information obtained from teachers opinion, it is hoping that the changes made between similar letterforms to be useful in the process of learning to read in individuals with autism.

The literature and the results from interviews and survey show that reading patterns of individuals with autism are variable and cannot be generalized. Because while some individuals with autism may have a hyperlexia reading profile, others can show poor word reading performance. The following information can be said;

Individuals with autism may need stimuli to differentiate shapes that look similar to each other. Other problems that may be faced by individuals include: Reading the word with the missing letter (like lift= lit, lft, ift). Reading the word with responding different letter in the word and/or blending the letter (as an example; reading the word elephant like a elephanl or cat-caf). Has difficulty with learning letter names and mixing sounds they make with similar letters. Confuses letters that look similar (b, d, p, q...).

Care should be taken when working with individuals who require special needs, such as autism, and special education. It is important to review previous research on individuals with autism. According to our study, It can be useful for this group to increase the differences between the letterforms without disturbing the typeface harmony. Also, it can be tried to make more space between letterforms for letterform jumping problem. But these changes have to be tested on individuals with autism. it's not correct to mention about benefits, without testing typeface. As it is known, no significant correlation was found between autistic symptomatology and word reading within the ASD group, for this reason, it is important to design not only for autism but also for individuals who need special education.

It is hoped to contribute the existing literature by finding some difficulties of individuals with autism in learning to read and related to character recognition in this research. Broad-Based literature research has been conducted in the direction of the objectives of the thesis and the reading problems faced by the individual with autism have

been investigated. Unfortunately, much of the research about individuals with autism focuses on reading comprehension, therefore the following question was unanswered:

What are the benefits of typeface for individuals with an autism spectrum?

However, it was found in the literature that the poor word reading profile of individuals with autism does not characterize with dyslexia nor autistic symptoms. This result has led us to the assumption that learning difficulties can cause reading difficulties in individuals with autism. However, It is clear that it needs more scientific research for definitive conclusions.

It was developed a survey to answer our research question and to find out how to develop a typeface for testing on individuals with autism. The survey results made with experts in the education of autism provided us with the following information:

- Experts showed that the letter pairs which can cause misreadings in individuals with autism, these are b-p, d-p, d-q, f-t, m-n, a-e, i-l in English survey result. In addition, experts showed that letter pairs of c-ç, o-ö i-I, ı-i, g-ğ, s-ş can cause the misreading in Turkish survey.
- Some individuals with autism can have reading difficulties, but the cause can be unknown.
- The process of learning to read can be various on students with autism spectrum, therefore it can not be generalised. While some autistic students can have difficulties in reading and learning to read but some of them have not.

In addition, It was found that some of students with autism can have the following difficulties in learning to read and reading process.

- Reading a word with the missing letter.
- Has difficulty in learning the names of the letters and misusing the letters that have a similar sounds.
- Confused by the letters that looks similar.

Individuals with autism are known as good word readers. There are very few studies that say that autism has poor word reading subgroup. Due to lack of literature sources about the topic, the findings that presented in this research mainly came from collected opinions of the teachers who have been working in this field, therefore the further research is needed it. However, the survey results can help us to draw a conceptual frame about the subject. According to these conclusions, we believe that a typeface can be created for individuals with autism. We think that a new typeface designed according to the results of this study (teachers opinions, literature study) can be good for ensuring the needs of

teachers in teaching reading to individuals with autism or learning disability. However, to proof its effectiveness, the prototype (typeface) will have to be tested on teaching and eventually improved. The use of typeface that recommended in the fallowing areas;

V.1 and v.5 are suitable fonts for longer text. It can be used in illustrated reading books for children, in the bodies of large texts for print and screen.

V.2 v.3 v.4 are recommended to use in word reading studies according to individuals requirements, in Pecs system, letter-based and word-based learning systems, in titles or everywhere where the picture is presented with short text or word.

The Accessible font family stands out with their own characteristic features, which are simple letterforms, a high x-height, open counters forms, a strong regular weight and without contrast in letterforms. These features makes the accesible font legible and a clear typeface. In addition to this, the accessible font family has five different fonts, stylistic sets and extended characters that support almost 200 Latin-based languages. These features of the typeface family enable to cover accessible rules. For these reasons, we suggest to use Accessible font according to accessibility rules.

In future research, to fully understand the performance of this typeface, its legibility should be tested in individuals with autis and its functionality tested by their educators.

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4.7 Glossary

Letterforms	A letterform, letter-form or letter form, is a term used especially in typography, paleography, calligraphy and epigraphy to mean a letter's shape. A letterform is a type of glyph, which is a specific, concrete way of writing an abstract character or grapheme
Applied Behavior Analysis	Applied behavior analysis is a scientific discipline concerned with applying techniques based upon the principles of learning to change behavior of social significance.
ASD	Autism spectrum disorder (ASD) is the name for a range of similar conditions, including Asperger syndrome, that affect a person's social interaction, communication, interests and behaviour.
Asperger's Disorder	Asperger syndrome (AS), also known as Asperger's, is a developmental disorder characterized by significant difficulties in social interaction and nonverbal communication, along with restricted and repetitive patterns of behavior and interests.
Autism	Autism is a complex neurobehavioral condition that includes impairments in social interaction and developmental language and communication skills combined with rigid, repetitive behaviors. Because of the range of symptoms, this condition is now called autism spectrum disorder.
Childhood Disorder	Common childhood mental illnesses and developmental disorders include Depression, Bipolar Disorder and Anxiety Disorders, Autism and similar Pervasive Developmental Disorders, Attention Deficit and Hyperactivity Disorder, Learning Disabilities, Adjustment Disorders, Oppositional Defiant Disorder, and Conduct Disorder.

Decoding	Decoding is a key skill for learning to read. It involves sounding out words and blending the sounds together. Kids who struggle with decoding have trouble identifying the individual sounds that make up words.
Developmental Disorders	Developmental disorders comprise a group of psychiatric conditions originating in childhood that involve serious impairment in different areas. There are several ways of using this term. The narrowest concept is used in the category "Specific Disorders of Psychological Development" in the ICD-10.
External	Means that coming from the outside, The external element of the reading is to the words
Font	Font is a set of printable or displayable text character s in a specific style and size.
Grapheme	In linguistics, a grapheme is the smallest unit of a writing system of any given language. An individual grapheme may or may not carry meaning by itself, and may or may not correspond to a single phoneme of the spoken language.
Hyperlexia	Hyperlexia is a syndrome characterized by an intense fascination with letters or numbers and an advanced reading ability. Hyperlexic children read at levels far beyond those of their age mates and often begin reading at very young ages, sometimes at age two.
Internal	Internal definition, situated or existing in the interior of something; interior. The internal element of reading is the comprehension of the text.
Joint Attention	Joint attention is a pre-communication skill in which an adult and a young child attend to the same object or event. Gestures and eye gaze are usually the key indicators of joint attention.
Learning disabilities	Learning disabilities are neurologically-based processing problems. These processing problems can interfere with learning basic skills such as reading, writing and/or math. They can also interfere with higher level skills such as organization, time planning, abstract reasoning, long or short-term memory and attention.
Legibility	Legibility is the ease with which a reader can recognize individual characters in text. The legibility of a typeface is related to the characteristics inherent in its design ... which relate to the ability to distinguish one letter from the other.
Lexical decisions	The lexical decision task is a procedure used in many psychology and psycholinguistics experiments. The basic procedure involves measuring how quickly people classify stimuli as words or nonwords.
Lexicon	In linguistics, a lexicon is a language's inventory of lexemes.
Orthographic lexicon	A lexical decision task was used to investigate the dual-route hypothesis that, in reading words conventionally written in katakana, a Japanese syllabic script, lexical access may be achieved by both a process of assembled segmental phonology and the use of a visual orthographic lexicon.

Orthography	The art of writing words with the proper letters according to standard usage. The representation of the sounds of a language by written or printed symbols. a part of language study that deals with letters and spelling.
PDD-NOS	PDD-NOS stands for Pervasive Developmental Disorder-Not Otherwise Specified. PDD-NOS was one of several previously separate subtypes of autism that were folded into the single diagnosis of autism spectrum disorder (ASD) with the publication of the DSM-5 diagnostic manual in 2013.
Phoneme	A phoneme is one of the units of sound that distinguish one word from another in a particular language
Phoneme awareness	Phonemic awareness is a subset of phonological awareness in which listeners are able to hear, identify and manipulate phonemes, the smallest mental units of sound that helps to differentiate units of meaning.
Phonetics	Phonetics deals with the articulatory and acoustic properties of speech sounds, how they are produced, and how they are perceived.
Phonics	Phonics instruction helps children learn the relationships between the letters of written language and the sounds of spoken language. Children are taught, for example, that the letter n represents the sound /n/, and that it is the first letter in words such as nose, nice and new.
Phonological	The phonological system of a language includes. an inventory of sounds and their features, and. rules which specify how sounds interact with each other.
Phonology	Phonology is a branch of linguistics concerned with the systematic organization of sounds in languages
Readability	Readability is the ease with which a reader can understand a written text. In natural language, the readability of text depends on its content (the complexity of its vocabulary and syntax) and its presentation (such as typographic aspects like font size, line height, and line length).
Semantic	Semantics is the linguistic and philosophical study of meaning, in language, programming languages, formal logics, and semiotics.
Sight word	Sight words is a common term in reading that has a variety of meanings. When it is applied to early reading instruction, it typically refers to the set of about 100 words that keeps reappearing on almost any page of text. “Who, the, he, were, does, their, me, be” are a few examples.
Stimulus	A stimulus is something that causes a physiological response
Symbol usage	The symbol usage is the education method by using card and symbols, in the education of the individuals with autism.

Typeface	In typography, a typeface (also known as font family) is a set of one or more fonts each composed of glyphs that share common design features. Each font of a typeface has a specific weight, style, condensation, width, slant, italicization, ornamentation, and designer or foundry (and formerly size, in metal fonts).
Visual learners	Visual learning is a style in which a learner utilizes graphs, charts, maps and diagrams. Also, individuals with autism are visual learners.
Characters	A character reference (also known as a personal reference) is a letter written by someone who knows the job candidate and can speak to his or her character and abilities. Unlike professional references, the person writing the reference is not an employer.

ATTACHMENTS

5.1 Accessible Font

Accessible Font

Regular v.1, v.2, v.3, v.4

Accessible typeface family was created based on the practices of the educators, typeface designers and researchers in the fields of psychology. The aim of the typeface study is to find solutions to the problems of the individuals who have difficulties in reading and the process of learning to read.

The accessible font was designed with a high x-height, different letterform combinations and reducing similarities between letterforms. The Accessible stand out with extended characters that support almost 200 Latin-based languages, covering math symbols, punctuation, and currencies.

Accessible font family is a simple and harmonious appearance as well as it offers great customization support to the pedagogues with differences in letterform design and stylistic combinations. As a result, a typeface is appeared to meet the individual requirements in which the teachers can change the character design according to students needs. This makes the Accessible font ac-

cessible for everyone.

The accessible font family consist of 5 fonts and each font has at least one stylish alternative. These fonts have different glyphs combination and forms that ensure us to address different individuals needs in the reading performance.

The elements that disturb the reader are avoided and a regular form was tried to be obtained in Accessible Font Regular v.1. The aim was to reveal a font using only the factors affecting legibility. These factors are x-heigh, counters and terminals. It can see the structure and feature of the v.1 font in detail below.

Regular v.1

a b d f c u ü

Regular v.2

a b d f c u ü

Regular v.3

a b d f c u ü

Regular v.4

a b d f c u ü

Regular v.5

a b d f c u ü

Accessible Font Regular v.2

The Regular v.2 font was designed especially for individuals who have difficulties in distinguishing letterforms between basic Latin and extended characters. Serif features were applied on extended letterforms so that extended letterforms were separated from the basic Latin characters as a different shape. This hybrid version was developed to help the individuals who learn reading with letter-based learning system but, it can use in the word-based learning system to identify better the characters in the word. The letterforms o and ö contain different forms order to have distinctive shape. The teacher can choose the set 1 option and convert the serif character to sans serif so that only the letterforms of 'a, b, d, p, q, f' stays as different letterforms from v.1. Set 2 provides to swap the serif feature on the extended characters to basic Latin characters.. In this way, basic characters will have serif but extended characters will not have serif feature.

Multilingual

Differences from v.1

Öğrenmek için	a	b	d	p	q
Çeşitli maddeler	a	b	d	p	q
Óbidos é visãõ	ü	ö	i	ş	ğ
Statistical view	ü	ö	i	ş	ğ
Straße wäre	u	o	i	s	g

*The grey characters are belong to Regular v.1 and the black characters are the Regular v.2

Basic Latin

A B C D E F G H I J K L M
 N O P Q R S T U V W X Y Z
 a b c d e f g h i j k l m
 n o p q r s t u v w x y z

Basic Latin
 Stylish
 Alternatives
 ss.01

A B C D E F G H I J K L M
 N O P Q R S T U V W X Y Z
 a b c d e f g h i j k l m
 n o p q r s t u v w x y z

Basic Latin
 Stylish
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 ss.02

A B C D E F G H I J K L M
 N O P Q R S T U V W X Y Z
 a b c d e f g h i j k l m
 n o p q r s t u v w x y z

Basic Latin

ö o ü u i l

Stylistic
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 ss.01

ö o ü u i l

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English Regular v.2 14 pt.

New York City comprises 5 boroughs sitting where the Hudson River meets the Atlantic Ocean. At its core is Manhattan, a densely populated borough that's among the world's major commercial, financial and cultural centers. Its iconic sites include skyscrapers such as the Empire State Building and sprawling Central Park. Broadway theater is staged in neon-lit Times Square. Major Atlantic Coast cities are New York.

Polish Regular v.2 14 pt.

Monachium, stolica Bawarii, jest domem dla wielowiekowych budynków i licznych muzeów. Miasto słynie z dorocznych obchodów Oktoberfest i piwnych sal, w tym słynnego Hofbräuhaus, założonego w 1589 roku. W Altstadt (Stare Miasto), centralny plac Marienplatz zawiera zabytki, takie jak neogotycki Neues Rathaus (ratusz), z popularny show z glockenspiel, który odtwarza i odtwarza historie z XVI wieku.

Portuguese Regular v.2 14 pt.

Lisboa é a capital de Portugal, cuja história circula à volta da sua posição geográfica estratégica no estuário do maior rio da Península Ibérica, o Tejo; do seu porto natural ser o melhor para o reabastecimento dos barcos que fazem o comércio entre o Mar do Norte e o Mediterrâneo; além da sua proximidade no extremo Sul e Ocidente da Europa, com os novos continentes da África Subsahariana e da América

Turkish Regular v.2 14 pt.

İstanbul'un tarihi 300 bin yıl önceye kadar uzanır. Küçükçekmece gölü kenarında bulunan Yarımburgaz mağarasında yapılan kazılarda insan kültürüne ait ilk izlere rastlanmıştır. Bu dönemde gölün çevresinde Neolitik ve Kalkolitik insanların yaşadığı sanılmaktadır. İzmir şehrinde görmenizi tavsiye ederiz. 1923'te Ankara'nın başkent olmasıyla birlikte köklü başkentlik özelliğini kaybeden İstanbul, 4. yüzyıldan 18. yüzyıla kadar.

Turkish Regular v.2 ss.02 14 pt.

New York City comprises 5 boroughs sitting where the Hudson River meets the Atlantic Ocean. At its core is Manhattan, a densely populated borough that's among the world's major commercial, financial and cultural centers. Its iconic sites include skyscrapers such as the Empire State Building and sprawling Central Park. Broadway theater is staged in neon-lit Times Square. Major Atlantic Coast cities are New York.

Polish Regular v.2 ss.02 14 pt.

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Portuguese Regular v.2 ss.02 14 pt.

Lisboa é a capital de Portugal, cuja história circula à volta da sua posição geográfica estratégica no estuário do maior rio da Península Ibérica, o Tejo; do seu porto natural ser o melhor para o reabastecimento dos barcos que fazem o comércio entre o Mar do Norte e o Mediterrâneo; além da sua proximidade no extremo Sul e Ocidente da Europa, com os novos continentes da África Subsahariana e da América

Turkish Regular v.2 ss.02 14 pt.

İstanbul'un tarihi 300 bin yıl önceye kadar uzanır. Küçükçekmece gölü kenarında bulunan Yarımburgaz mağarasında yapılan kazılarda insan kültürüne ait ilk izlere rastlanmıştır. Bu dönemde gölün çevresinde Neolitik ve Kalkolitik insanların yaşadığı sanılmaktadır. İzmir şehrinde görmenizi tavsiye ederiz. 1923'te Ankara'nın başkent olmasıyla birlikte köklü başkentlik özelliğini kaybeden İstanbul, 4. yüzyıldan 18. yüzyıla kadar.

Regular v.2 6 pt.

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Regular v.2 8 pt.

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Regular v.2 9 pt.

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Regular v.2 10 pt.

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Regular v.2 11 pt.

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Regular v.2 14 pt.

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Regular v.2 48 pt.

The City

Accessible Font Regular v.3

The Regular v.3 typeface was designed specifically for individuals who have difficulty in distinguishing similar letterforms. In Regular v.3 font, the main purpose of the design was to distinguish the similar letterform glyphs, but in doing so, attention was put on to not to disturb the harmony and balance in the typeface family. It has been tried to reduce the similarities by adding serif features and different character shapes on similar letterforms (like b, d, p, q). In addition to these features, V.3 extended letterforms have serif features from V.2 and are coded as set 1. So teachers can combine features of Regular v.2 with Regular v.3. If the teachers wants to swap the serif between basic Latin letterforms and extended letterforms, they can use set 2.

Multilingual

Differences from v.2

Öğrenmek için	a	b	d	p	q
Ꞑēniņš mācītes	a	b	d	p	q
Óbidos é visão	ü	ö	i	ş	ğ
Statistical view	ü	ö	i	ş	ğ
Straße wäre	u	o	i	s	g

*The grey characters are belong to Regular v.2 and the black characters are the Regular v.3

Basic Latin

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
a	b	c	d	e	f	g	h	i	j	k	l	m
n	o	p	q	r	s	t	u	v	w	x	y	z

Basic Latin Stylish Alternatives ss.01

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
a	b	c	d	e	f	g	h	i	j	k	l	m
n	o	p	q	r	s	t	u	v	w	x	y	z

Basic Latin Stylish Alternatives ss.02

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
a	b	c	d	e	f	g	h	i	j	k	l	m
n	o	p	q	r	s	t	u	v	w	x	y	z

Basic Latin

b	d	ü	u	ö	y
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Stylistic Alternatives ss.01

b	d	ü	u	ö	y
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b	d	ü	u	ö	y
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Regular v.3 6 pt.

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Regular v.3 8 pt.

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Regular v.3 14 pt.

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The City of

Regular v.3 48 pt.

The City of

Accessible Font Regular v.4

It was followed an approach to reduce the harmony between the characters and its the similarities as much as possible while designing the regular v.4 font. The main feature of v.4 is that there are more elements that can disturb the reader than v.3. It is a version thought to give greater autonomy to the identification of the characters (to the legibility) in detriment of the readability. On this design, while some extended Latin characters have serifs, some characters have not serif. So, in the design of v.2, all the extended Latin characters come with serif, while in v.4 design they only some characters (s-ş,g-ğ,c-ç,i-ı,ü-u,o-ö) come with serif. These some characters are letterform pairs obtained from the results of the Turkish survey, which can lead to reading errors.

In v.4 font, the characters 'a', 'b', 'e', 'h', 'n', and 'p' were designed in a different shape from the v.3. In this way, care was taken to increase the differences between the letterforms compared to v.3. Below, you can see differences between the versions.

Multilingual

Differences from v.3

Öğrenmek için a b d p q

Çeşitli maddeler a b d p q

Óbidos é visão ü ö i ş ğ

Statistical view ü ö i ş ğ

Straße wäre u o l s g

*The grey characters are belong to Regular v.2 and the black characters are the Regular v.3

Basic Latin

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z

Basic Latin Stylish Alternatives ss.01

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z

Basic Latin Stylish Alternatives ss.02

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m
n o p q r s t u v w x y z

Basic Latin

ö o ü u i i l l

Stylistic Alternatives ss.01

ö o ü u i i l l

Stylistic Alternatives ss.02

ö o ü u i i l l

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Regular v.4 24 pt.

The City of New York, usually called ei-

Regular v.4 30 pt.

The City of New York, usually

Regular v.4 36 pt.

The City of

Regular v.4 48 pt.

The City of

Regular v.4 6 pt.

The City of New York, usually called either New York City (NYC) or simply New York (NY), is the most populous city in the United States and thus also in the state of New York. With an estimated 2017 population of eight million distributed over a land area of about 302.6 square miles (784 km2), New York is also the most densely populated major city in the United States. Located at the southern tip of the state of New York, the city is the center of the New York metropolitan area, the largest metropolitan area in the world by urban landmass and one of the world's most populous megacities, with an estimated twenty million people in its 2017 Metropolitan Statistical Area and 23,876,155 residents in its Combined Statistical Area A global power city New York

Regular v.4 8 pt.

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Regular v.4 10 pt.

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Regular v.3 11 pt.

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Regular v.4 12 pt.

İstanbul'un tarihi 300 bin yıl önceye kadar uzanır. Küçükçekmece gölü kenarında bulunan Yarımburgaz mağarasında yapılan kazılarda insan kültürüne ait ilk izlere rastlanmıştır. Bu dönemde gölün çevresinde

Regular v.4 14 pt.

The City of New York, usually called either New York City (NYC) or simply New York (NY), is the most populous city in the United States and thus

Regular v.4 18 pt.

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The City of

Regular v.4 48 pt.

The City of

New York City comprises 5 boroughs sitting where the Hudson River meets the Atlantic Ocean. At its core is Manhattan, a densely populated borough that's among the world's major commercial, financial and cultural centers. Its iconic sites include skyscrapers such as the Empire State Building and sprawling Central Park. Broadway theater is staged in neon-lit Times Square. Major Atlantic Coast cities are New York.

Monachium, stolica Bawarii, jest domem dla wielowiekowych budynków i licznych muzeów. Miasto słynie z dorocznych obchodów Oktoberfest i piwnych sal, w tym słynnego Hofbräuhaus, założonego w 1589 roku. W Altstadt (Stare Miasto), centralny plac Marienplatz zawiera zabytki, takie jak neogotycki Neues Rathaus (ratusz), z popularny show z glockenspiel, który odtwarza i odtwarza historie z XVI wieku.

Lisboa é a capital de Portugal, cuja história circula à volta da sua posição geográfica estratégica no estuário do maior rio da Península Ibérica, o Tejo; do seu porto natural ser o melhor para o reabastecimento dos barcos que fazem o comércio entre o Mar do Norte e o Mediterrâneo; além da sua proximidade no extremo Sul e Ocidente da Europa, com os novos continentes da África Subsahariana e da América

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Regular v.5 6pt

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English Regular v.5 14pt

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Regular v.5 36pt

The City of

Regular v.5 48pt

The City

v.1 Öğrenmek için

v.2 Öğrenmek için

v.3 Öğrenmek için

v.4 Öğrenmek için

v.5 Öğrenmek için

v.1 Óbidos é visão

v.2 Óbidos é visão

v.3 Óbidos é visão

v.4 Óbidos é visão

v.5 Óbidos é visão

5.2 English Survey