UNIVERSITY OF IOANNINA
SCHOOL OF EDUCATION
DEPARTMENT OF PRIMARY EDUCATION

“Design guidelines for Virtual Environments for individuals with Autism Spectrum Disorders: a Delphi Study”

Aikaterini Kalyvioti

Ph.D. Thesis

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ABSTRACT

VR technologies and their qualities (affordances) are viewed as a unique tool with significant potential benefits for supporting (intervening/training) individuals with autism. Researchers have developed several virtual environments and applications for the training of numerous skills (e.g., social, communication, daily living/functional, behavioral, emotional, sensory, and motor skills). Currently, there are no universal or specific design guidelines for developing such virtual environments. However, there have been a few attempts at their description that are primarily based on VR's affordances.

Thus, we attempted to provide a comprehensive framework of design guidelines for virtual environments that target the training of skills of individuals with autism. The proposed design guidelines were organized per four autism profiles (i.e., mild ASD with and without ID, severe ASD with and without ID) and targeted training skills. Each design guideline had 4 (+1) components/elements, depending on whether all five reached the set consensus level. Those components/elements were the VR combination, i.e., the VR system, VR affordance, VR learning affordance, VR task/activity, and the individual's specific skill set (ISSS). The four VR-related components/elements clearly expand and differentiate the current, somewhat broader approach of an affordances-based design for these virtual environments. The fifth component/element of ISSS (i.e., the set of skills that will help the user gain benefit from the administered virtual environment) highlights the user-centered approach of these proposed design guidelines.

Thus, while having an expanded affordances-based and user-centered approach, we employed a three-round e-Delphi study (which has its basis in the classical Delphi). The expert panel consisted of international researchers, academics, and scholars from the research fields of autism and VR. Additionally, each questionnaire was pilot-tested, and a summary of the results from each round was provided to the experts. In Round 1, 22

experts responded to our invitation and completed the first questionnaire, which included both open-ended and demographic questions. Their answers were analyzed (content analysis) and led to the development of Round 2’s questionnaire, where 13 experts participated in that round. After filtering Round 2’s answers, the questionnaire for the last round was developed, and eight experts participated in Round 3 of the study. In this final round, a minimum of 75% consensus was reached for 47 out of the 65 suggested design guidelines (statements).

We present all 47 suggested guidelines, along with an overview of each one by clinical profile. Thus, we follow a three-tier approach regarding the study's conclusions, i.e., the framework for the design guidelines (VR combinations & ISSS), the general design guidelines per (clinical) profile, and lastly the specific 47 design guidelines per profile and targeted skill. Lastly, given the broad scope of our study and the absence of empirical application of the suggested design guidelines, we propose that future work address these two main limitations by testing the proposed guidelines and further exploring them for the educational benefit of individuals with autism.

ΠΕΡΙΛΗΨΗ

«Προδιαγραφές σχεδίασης Εικονικών Περιβαλλόντων
για άτομα με διαταραχές Αυτιστικού φάσματος: μία μελέτη Delphi»

Οι τεχνολογίες Εικονικής Πραγματικότητας (ΕΠ) και οι «δυνατότητές» τους (affordances) θεωρούνται ένα μοναδικό εργαλείο με σημαντικά πιθανά οφέλη για άτομα με αυτισμό (παρέμβαση/εκπαίδευση). Ερευνητές έχουν αναπτύξει ποικίλα εικονικά περιβάλλοντα και εφαρμογές για την εξάσκηση πολυάριθμων δεξιοτήτων (π.χ., κοινωνικές, επικοινωνιακές, λειτουργικές δεξιότητες, δεξιότητες ζωής, συμπεριφορικές, συναισθηματικές, αισθητηριακές και κινητικές). Μέχρι στιγμής δεν υπάρχουν κοινά αποδεκτές ή συγκεκριμένες προδιαγραφές σχεδίασης για την ανάπτυξη τέτοιων εικονικών περιβαλλόντων. Παρόλα αυτά έχουν υπάρξει προσπάθειες περιγραφής τους που βασίζονται κυρίως στις «δυνατότητες» (affordances) της ΕΠ.

Με την παρούσα μελέτη προσπαθήσαμε να δώσουμε ένα ολοκληρωμένο πλαίσιο (framework) προδιαγραφών σχεδίασης για εικονικά περιβάλλοντα για την εξάσκηση δεξιοτήτων ατόμων με αυτισμό. Οι προτεινόμενες προδιαγραφές σχεδίασης έχουν οργανωθεί βάσει τεσσάρων κλινικών προφίλ αυτισμού (δηλ., ήπιος αυτισμός με/χωρίς νοητική υστέρηση, βαρύς αυτισμός με/χωρίς νοητική υστέρηση) και ανά στοχευμένη δεξιότητα. Κάθε προτεινόμενη προδιαγραφή σχεδίασης έχει 4 (+1) στοιχεία/μέρη αναλόγα με το ποια από αυτά σημείωσαν συναίνεση μεταξύ των ειδικών. Τα στοιχεία/μέρη ήταν το σύστημα ΕΠ (VR system), η ΕΠ «δυνατότητα» (VR affordance), η ΕΠ εκπαιδευτική «δυνατότητα» (VR learning affordance), η ΕΠ δοκιμασία/δραστηριότητα (VR task/activity) (όλα μαζί συνιστούν τον συνδυασμό ΕΠ, VR combination) και οι δεξιότητες του ατόμου/χρήστη (ISSS, Individual’s Specific Skill Set). Τα τέσσερα στοιχεία που σχετίζονται με την ΕΠ επεκτείνουν και διαφοροποιούνται από την μέχρι τώρα σχετικά ευρεία προσέγγιση για τις προδιαγραφές σχεδίασης τέτοιων

εικονικών περιβαλλόντων. Το πέμπτο στοιχείο ISSS (δηλ., οι δεξιότητες εκείνες που θα βοηθήσουν τον χρήστη να έχει όφελος από το εικονικό περιβάλλον) δίνουν έμφαση σε μία πιο ανθρωποκεντρική προσέγγιση των προτεινόμενων προδιαγραφών σχεδίασης.

Συνεπώς και έχοντας μία εκτενέστερη προσέγγιση με βάσει τις «δυνατότητες» και τον χρήστη, διεξάγαμε μία e-Delphi μελέτη (βασίζεται στην κλασική Delphi) που αποτελούνταν από τρεις γύρους. Το διεθνές πάνελ των εμπειρογνώμων αποτελούνταν από ερευνητές και ακαδημαϊκούς από τους ερευνητικούς χώρους του αυτισμού και της ΕΠ. Επίσης, κάθε ερωτηματολόγιο ελέγχθηκε πιλοτικά ενώ σε κάθε γύρο οι ειδικοί λάμβαναν περίληψη των αποτελεσμάτων του. Στον πρώτο γύρο συμμετείχαν 22 ειδικοί οι οποίοι συμπλήρωσαν το αρχικό ερωτηματολόγιο με ανοιχτού και δημογραφικού τύπου ερωτήσεις. Οι απαντήσεις τους αναλύθηκαν (ανάλυση περιεχομένου) και οδήγησαν στον σχεδιασμό του ερωτηματολογίου του δεύτερου γύρου το οποίο συμπλήρωσαν 13 ειδικοί. Η ίδια διαδικασία επαναλήφθηκε στον τρίτο και τελευταίο γύρο της μελέτης όπου οι οκτώ ειδικοί που συμμετείχαν, συναίνεσαν σε 47 από τις 65 προτεινόμενες προδιαγραφές σχεδίασης (75% στατιστικό κριτήριο).

Αναφορικά με τα συμπεράσματα της μελέτης αυτής τα προσεγγίζουμε σε τρία επίπεδα Το πρώτο και αρχικά γενικότερο επίπεδο αφορά το μοντέλο περιγραφής των προδιαγραφών σχεδίασης και των 4 (+1) μερών του. Το δεύτερο επίπεδο αναφέρεται στις γενικότερες αρχές προδιαγραφές σχεδίασης ανά (κλινικό) προφίλ και τρίτο επίπεδο στις αναλυτικότερες 47 προτεινόμενες και αποδεκτές από το πάνελ των ειδικών προδιαγραφών σχεδίασης. Αναφορικά με τους ερευνητικους περιορισμούς, το ευρύ πεδίο μελέτης και η απουσία εμπειρικής εφαρμογής των προδιαγραφών σχεδίασης αποτελούν τους κυρίως περιορισμούς. Προτείνουμε μελλοντικά τη διερεύνηση και εμπειρικό έλεγχο των προτεινόμενων προδιαγραφών σχεδίασης περιβαλλόντων εικονικης πραγματικότητας για την αξιοποίησή τους στην εκπαίδευση (skills training) ατόμων με αυτισμό.

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TABLE OF CONTENTS

Abstract vi

Περίληψη viii

Acknowledgements xi

Table of Contents xiii

Chapter 1: Autism Spectrum Disorder 1

1.1 Introduction 2

1.2 Historical background and an overview of diagnostic approaches 2

1.2.1 Kanner's report 2

1.3 Definition 3

1.3. 1 DSM-5: 299.00 Autism Spectrum Disorder 5

1.3.2 ICD-10: F84.0 Childhood autism 6

1.4 Epidemiology 6

1.4.1 Prevalence Estimates 7

1.4.2 Autism prevalence estimates in Greece 9

1.5 Etiology 10

1.5.1 Genetic factors 11

1.5.2 Environmental factors 12

1.6 Interventions for autism for children and adults 14

1.6.1 Behavioral and pharmacological interventions in children 14

1.6.2 Behavioral and pharmacological interventions for adults 18

1.7 ICT Interventions in Autism 18

1.7.1 Computer-based systems 18

1.7.2 Virtual Reality technologies and autism 19

1.8 Summary 20

Chapter 2: Virtual Reality 21

2.1 Introduction 21

2.2 Immersive technology 21

2.3 Forms of Reality: virtuality continuum 21

2.4 Definition of Virtual Reality 23

2.5 Augmented Reality 25

2.6 History of VR 26

2.6.1 The 1800s 26

2.6.2 The 1900s 28

2.6.3 The 2000s 29

2.7 VR technologies: systems and types 29

2.7.1 VR systems 29

2.7.2 VR system types and hardware 30

2.7.2.1 Non-immersive VR systems 31

2.7.2.2 Semi-immersive VR systems 32

2.7.2.3 (Fully) Immersive VR systems 32

2.7.2.4 Distributed-VR 33

2.8 Affordances: VR affordances and learning affordances 33

2.8.1 Affordances 34

2.8.2 VR affordances 35

2.8.2.1 Presence 35

2.8.2.2 Immersion 35

2.8.2.3 Presence versus immersion 36

2.8.2.4 Avatars 36

2.8.2.5 Other VR affordances 37

2.8.3 VR learning affordances 37

2.8.3.1 Overlapping of learning affordances in literature 39

2.9 VR learning activities (task categories classification) 40

2.10 VR in education 43

2.11 VR and Autism 44

2.11.1 VR for social skills in autism 45

2.11.2 VR for communication skills in autism 46

2.11.3 VR for cognitive skills in autism 48

2.11.4 VR for daily living functional skills in autism 49

2.11.5 VR for sensorimotor skills in autism 50

2.11.6 VR for behavioral and emotional skills in autism 51

2.12 Summary 53

Chapter 3: The Delphi Technique 54

3.1 Introduction 54

3.2 History of the Delphi technique 54

3.3 Definition of the Delphi technique 55

3.4 The Delphi process: the original Delphi (Classical Delphi) 56

3.5 Priority setting versus consensus 57

3.5.1 Non-consensus Delphi 57

3.6 Types of Delphi 58

3.7 Sampling and the use of experts 60

3.7.1 Defining 'expert' and employing an expert panel 60

3.7.2 Size of the expert panel 61

3.7.3 Valid opinion 61

3.8 Anonymity 62

3.8.1 Quasi-anonymity 62

3.8.2 Group dynamics 63

3.9 Delphi rounds 63

3.9.1 Round 1 64

3.9.2 Subsequent rounds 65
3.10 Response rates 66
3.10.1 Enhancing response rate 66
3.11 Consensus 67
3.11.1 Consensus in expert panels 67
3.11.2 Concept of consensus 68
3.12 Comparison of Delphi with other consensus methods 68
3.12.1 Nominal group technique 68
3.12.2 Consensus conference 69
3.13 Limitations of the Delphi 69
3.13.1 Pressures of conformity 70
3.14 Summary 71
Chapter 4: Literature review 72
4.1 Introduction 72
4.2 Literature reviews for VR and autism 73
4.3 Literature reviews for design guidelines for VR and autism 74
4.3.1 Systematic literature review for design guidelines for VR and autism 75
4.4 Systematic literature review 76
4.5 Step 1: Framing questions for a review 76
4.6 Step 2: Identifying relevant work 76
4.6.1 Definitions of terms for establishing the scope of the review 76
4.6.2 Search strategy and terms 78
4.6.3 Databases 79
4.6.4 Inclusion and exclusion criteria 80
4.7 Step 3: Assessing the quality of studies 81
4.8 Step 4: Summarizing the evidence 81

4.9 Step 5: Reporting the findings 82
4.9.1 SR-Q1: What affordances (design guidelines) are used? 82
4.9.2 SR-Q2: What VR technologies are utilized? 82
4.9.3 SR-Q3: What skills are targeted? 83
4.10 Current Delphi research for autism and virtual reality 83
4.11 Aim of the study 85
4.11.1 Why is autism research important? 85
4.11.2 Why are Virtual Reality and design guidelines significant in autism research? 87
4.11.3 Why use a Delphi study? 87
Chapter 5: Methodology and Materials 90
5.1 Introduction 90
5.2 Classical Delphi as a foundation for e-Delphi 90
5.3 In preparation for the study 91
5.4 Delphi participants 92
5.4.1 Eligibility criteria 92
5.5 Setting a consensus level 93
5.6 Pilot and mini pilot study 94
5.6.1 Mini pilot study 94
5.6.2 Member recruitment 95
5.6.3 Panel size 95
5.6.4 Means 96
5.6.5 Pilot study's interviewer 97
5.7 Round 1 98
5.7.1 Pilot and mini pilot study 98
5.7.2 Questionnaire 98
5.7.3 Administration 101

5.7.4 Data collection and analysis (qualitative content analysis, inductive and deductive) 102
5.7.4.1 Data collection 102
5.7.4.2 Data analysis 102
5.7.4.3 Qualitative content analysis 103
5.7.4.4 Triangulation 105
5.7.5 Individual and group summaries 106
5.7.5.1 Individual summary 106
5.7.5.2 Group summary 107
5.8 Round 2 108
5.8.1 Pilot & mini pilot study (questionnaire, instructions, group summary) 108
5.8.1.1 Questionnaire (two drafts) 108
5.8.1.2 Instructions 109
5.8.1.3 Group summary 109
5.8.2 Questionnaire 109
5.8.2.1 First draft questionnaire (abandoned) 109
5.8.2.2 Second draft questionnaire (adopted) 110
5.8.3 Administration 114
5.8.4 Data collection and analysis 114
5.8.5 Group summary 115
5.9 Round 3 115
5.9.1 Pilot & mini-pilot study 116
5.9.1.1 Questionnaire 116
5.9.1.2 Instructions 116
5.9.2 Questionnaire 116
5.9.3 Administration 118
5.9.4 Data collection and analysis 119

5.10 Ethical considerations 119
Chapter 6: Results 121
6.1 Introduction 121
6.1.1 Descriptive statistics 121
6.1.2 Measures of central tendency and measures of spread 121
6.1.3 Mode 122
6.2 Results of Round 1 122
6.2.1 Demographic data 124
6.2.2 Open-ended questions 127
6.3 Results of Round 2 129
6.3.1 Results of Round 2: Profile-1, Mild ASD with ID 132
6.3.2 Results of Round 2: Profile-2, Mild ASD without ID 135
6.3.3 Results of Round 2: Profile-3, Severe ASD with ID 138
6.3.4 Results of Round 2: Profile-4, Severe ASD without ID 141
6.4 Results of Round 3 144
6.4.1 Results of Round 3: Profile-1, Mild ASD with ID 147
6.4.2 Results of Round 3: Profile-2, Mild ASD without ID 152
6.4.3 Results of Round 3: Profile-3, Severe ASD with ID 156
6.4.4 Results of Round 3: Profile-4, Severe ASD without ID 160
Chapter 7: Discussion 167
7.1 Introduction 167
7.2 Design guidelines for: Profile-1 (Mild ASD with ID) 168
7.3 Design guidelines for: Profile-2 (Mild ASD without ID) 175
7.4 Design guidelines for Profile-3 (Severe ASD with ID) 180
7.5 Design guidelines for: Profile-4 (Severe ASD without ID) 185
7.6 Conclusions 193
7.6.1 Tier-1: the framework for the design guidelines 193

7.6.2 Tier-2: the general design guidelines per profile 193
7.6.3 Tier-3: the specific design guidelines per profile and targeted skills 194
7.7 Limitations 195
7.7.1 Broad study scope 195
7.7.2 Lack of empirical testing 196
7.7.3 Other limitations 197
7.8 Future work 198
Bibliography 200
B.1.1 References (in English) 200
B.1.2 References (in Greek) 236
B.2 Webpages 236
B.3 Other (Presentations) 138
Appendix A 240
Appendix B 245
Appendix C 258

Chapter 1

AUTISM SPECTRUM DISORDER

1.1 Introduction

Autism is a multifactorial neurodevelopmental disorder (Haroon, 2019). Researchers utilize different disciplines (e.g., genetics, neuroscience, and immunology) to identify its etiology and, consequently, develop treatments (McDougle, 2016). The Centers for Disease Control and Prevention (CDC) recently reported that autism affects 1 in 54 children in the U.S. (Maenner et al. 2020). More specifically, Maenner et al. (2020) reported that in 2016, about 1.85% (i.e., 1 in 54) of 8-year-old children were diagnosed with autism. These numbers reflect the findings in 11 US ADDM (Autism and Developmental Disabilities Monitoring) communities (Arizona, Arkansas, Colorado, Georgia, Maryland, Minnesota, Missouri, New Jersey, North Carolina, Tennessee, and Wisconsin). Epidemiology studies reveal overall elevated estimated percentages of children identified with autism (Haroon, 2019; Shaw et al., 2020; Maenner et al., 2020). As McDougle (2016) points out, one likely knows or has met an individual with an autism-related disorder.

The increase in the number of individuals with autism leads to increased needs for qualified providers and specialized health care, education, and service providers. It also highlights the effectiveness and continuum of benefit of autism awareness, screenings, early identification, diagnostic procedures, and evidence-based interventions throughout the lifespan of individuals with autism (Shaw et al., 2020; Maenner et al., 2020). It is noteworthy that several behavioral, psychological, pedagogical, medical (e.g., pharmacological, genetic), and technological approaches exist for autism treatment. Lastly, the developed interventions target a range of skills, including communication, socialization, and academics/learning (McDougle, 2016).

It is lastly noted that in this chapter and the dissertation overall, the terms ‘autism,’ ‘autism spectrum disorder(s)’ are used interchangeably yet consistently.

1.2 Historical background and overview of diagnostic approaches

In the 19th century, psychiatric disorders in adults (such as schizophrenia) and developmental disorders in children started to receive increased attention. Adults' psychological/mental disorders were being further studied, leading to their detailed description, clearer differentiation, and defined classification (psychiatric types/taxonomy). It was not long until there was also interest in children's psychological disorders. This sparked new research pathways and intervention approaches for children with developmental difficulties. Their study involved developmental factors that intersect with individuals' clinical/pathological profiles. Diagnostic systems such as the American Psychiatric Association's (APA) Diagnostic and Statistical Manual of Mental Disorders (DSM) and the World Health Organization's (WHO) International Classification of Diseases (ICD) started to be used for classification (classification systems) and diagnostic (diagnostic criteria) purposes (McDougle, 2016). Since the development of child psychiatry by Leo Kanner in 1935, both noteworthy and fallacious directions have been noted that have hence shaped our current knowledge and understanding of autism.

1.2.1 Kanner's report

As already mentioned, in 1943, Leo Kanner, a child psychiatrist at Johns Hopkins University School of Medicine, was the first to recognize, report, and publish his findings on what is today referred to as 'Autism Spectrum Disorder - ASD' (Kanner, 1943). His work involving 11 children with profound difficulty (if not even inability) to socialize is well known. He described their condition and documented its two key characteristics, i.e., significant social difficulties/social isolation (autism) and sameness insistence (change intolerance). In a rather insightful approach, Kanner was able to depict typical autism characteristics, including families' histories (e.g., educational backgrounds), discuss the probability of typical cognitive/intellectual functioning, and suggest that the exhibited condition was congenital (McDougle, 2016). Later studies supported that children with autism often exhibited cognitive and intellectual difficulties. Some splinter abilities were also occasionally reported (Goldstein, Naglieri, and Ozonoff, 2009; Harris, 2006).

During the 1960s and 1970s, robust research highlighted key pathological genetic (Folstein and Rutter, 1977) and neurobiological (Kolvin, 1972) factors. Fallacious assumptions such as the 1950s theory of "refrigerator mothers[1]" were debunked (Wing, 1980), and structured behavioral interventions were developed (Rutter and Bartak, 1973; McDougle, 2016). In the 1970s, and in a research-based approach, autism was established as a standalone diagnostic category with (mainly) two sets of diagnostic criteria. According to Rutter's guidelines (1978), the core characteristics of autism involve early manifestation of atypical social and communication development along with stereotypical behaviors and insistence on sameness. On the other hand, the National Society for Autistic Children (Ritvo and Freeman, 1978) focuses on autism's developmental irregularities and sensory difficulties (hyper- and hyposensitivity).

At that time, as a research-based and multiaxial approach to developmental disorders was emerging, the American Psychiatric Association (APA) implemented significant changes in its Diagnostic and Statistical Manual of Mental Disorders (DSM). The pertinent changes regarding autism's diagnostic criteria are reflected in the various editions of the DSM (Appendix A), with the DSM-III being the most prominent. Overall, diagnostic classifications support research, public health guidelines, communication, and service delivery (McDougle, 2016).

1.3 Definition

The term 'autism' derives from the Greek word "autos," and it means "self" (Baron-Cohen, 2005; Gene Blatt, 2020). It was first coined by the Swiss psychiatrist Eugen Bleuler in 1910 to describe the social withdrawal and self-isolation seen in individuals with schizophrenia (e.g., during episodes of delusions, hallucinations, disorganized thinking) (Evans, 2013). It was later, in the 1940s, that researchers in the United States began to use the term for children with social and emotional difficulties (Figure 1.1). Leo Kanner, who was at the time studying children with social

[1] According to this theory, it was the mothers' emotional neglect and lack of affection that caused autism (McDougle, 2016).

withdrawal at Johns Hopkins University, used ‘autism’ to describe those behaviors. Meanwhile, the German scientist Hans Asperger was also studying children with similar difficulties. Their condition was later referred to as Asperger’s syndrome. As previously mentioned, the scientific community had the belief that autism and schizophrenia were interconnected. Nonetheless, this misperception was abandoned in the 1960s when the two disorders were clinically and diagnostically differentiated (Baron-Cohen, 2005; Boucher, 2008; Evans, 2013; Cook and Willmerdinger, 2015; Haroon, 2019; Gene Blatt, 2020).

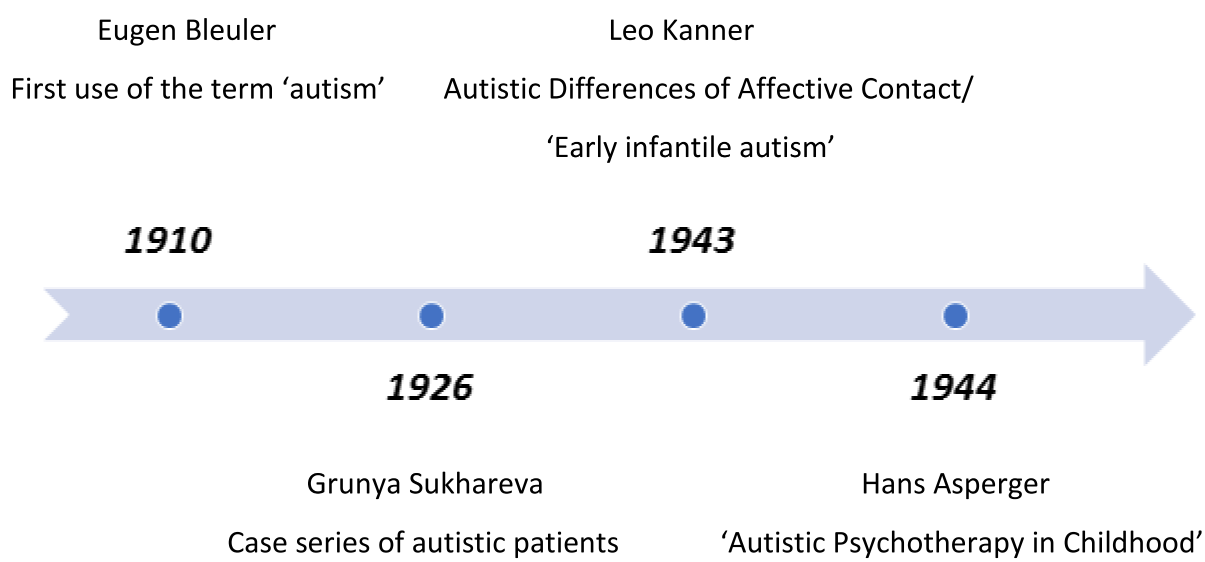


Figure 1:1 Timeline of the use of the term autism (Source: Haroon, 2019, p. 2; Boucher, p.5)

Today, we know that autism spectrum disorder is a neurodevelopmental and heterogeneous disorder. Regarding the use of the term ‘spectrum’, it reflects the clinical heterogeneity of the disorder from individual to individual. Furthermore, the literature highlights that the autistic phenotype can manifest differently in individuals and throughout their lifespan, with varying levels of symptom severity (Filipek et al., 1999; Boucher, 2008; Haroon, 2019). Also, individuals with autism can exhibit symptoms of other co-occurring conditions (comorbidity), both physiological and/or psychological (e.g., epilepsy, intellectual disability, anxiety, attention deficit hyperactivity disorder, learning disability) (McDougle, 2016; Haroon, 2019).

With autism's etiopathogenesis continuing not to be fully understood and known, this contributes to the use of many different terms (e.g., ‘autism spectrum condition’) and definitions for the condition. Thus, pertinent definitions state that impairments in social communication and interactions are present, and note the presence of repetitive behaviors, interests, and activities. These can manifest in different severities and across the individual's lifespan (Haroon, 2019).

Below are the definitions of autism from two prominent organizations, the American Psychiatric Association (APA) and the World Health Organization (WHO), and their own publications in their currently most recent editions, the Diagnostic and Statistical Manual, Fifth Edition (DSM-5, 2013) and the International Classification of Diseases, Tenth Revision (ICD-10: 2019) respectively (Boucher, 2008). The DSM-5, produced by a single national professional association, is used by healthcare professionals and providers primarily in the United States, Canada, and other countries. The ICD-10 is produced by a global health agency and used by the 193 WHO member countries (APA, 2009). Besides some differences in details and classification terminology, the two manuals are quite similar in their essence[2] (Boucher, 2008).

1.3. 1 DSM-5: 299.00 Autism Spectrum Disorder

The American Psychiatric Association’s Diagnostic and Statistical Manual, Fifth Edition (DSM-5) contains descriptions, symptoms, and other standardized criteria for diagnosing mental disorders, including autism (APA, 2009). There are two main categories of characteristics that an individual needs to exhibit persistent difficulties to receive an ASD diagnosis per the DSM-5: a) social communication and social interaction across multiple contexts, and b) restricted, repetitive

[2] It is noteworthy that the World Health Organization (WHO) has authorized clinical modifications (CM) of the ICD so that it is used as a source for diagnosis codes in the United States of America. Its most recent modification was the ICD-10-CM, which replaced the ICD-9-CM and was implemented by the US Congress in 2015 (https://www.cdc.gov/nchs/icd/icd10cm.htm).

patterns of behavior, interests, or activities. For a more detailed description of the pertinent diagnostic criteria, please refer to Appendix A for their complete description (DSM-5, 2013).

1.3.2 ICD-10: F84.0 Childhood autism

The ICD-10 was published in 1992, and similarly to the DSM-5, it classifies disorders/diseases while providing healthcare professionals with clear sets of diagnostic criteria. In its latest 1993 version (reprinted in 1997 and 2003), ICD-10 lists 'F84.0 Childhood autism' under the 'Pervasive developmental disorders'. The disorder is reported to manifest before the age of three years, presenting as atypical or impaired development. Also, the developmental areas impacted include reciprocal social interaction, communication, and restricted and repetitive behaviors. For a more detailed description of the pertinent diagnostic criteria, please refer to the ICD-10 (2019), pp. 147-149. Lastly, various versions of the ICD are available online, with the most recent ones being the ICD-10-CM online version and the ICD-11 online version, released in 2018 and expected to be used in 2022, according to the WHO's website (https://www.who.int/classifications/icd/en/).

1.4 Epidemiology

Autism prevalence has increased significantly in the last decades. Pertinent estimates vary from country to country due to differences in sample sizes, diagnostic characteristics (Elsabbagh et al., 2012), methodological variations in case detection, case definition, cultural influences, and case identification. Other contributing factors that can influence case assessment and therefore prevalence estimates include educational and healthcare system differences from country to country, the year of the study (Matson and Kozlowski, 2011), socioeconomic factors (Durkin et al, 2017; Durkin & Wolfe, 2020), and autism awareness (Hertz-Picciotto and Delwiche, 2009).

Accurate estimations of autism prevalence rates/numbers are necessary to determine the financial and healthcare costs of the disorder and thus the funds for service provision to individuals with autism (children and adults) and their families/caregivers. Therefore, an increase in the autism population, respectively, suggests an increase in services, service providers, and training (Boswell, Zablotsky, and Smith, 2014). It also suggests an increased need for identification of populations at higher risk due to geographical and environmental factors (Rice et al., 2012), disparities in healthcare access, and evaluations (Imm, White, and Durkin, 2019).

1.4.1 Prevalence Estimates

There have been several autism prevalence studies worldwide for the last 55 years. Two known reviews of such studies are from Elsabbagh et al. (2012) and Tsai (2014). The first one is a comprehensive review of almost 50 years of studies, up until the year of the review's publication. According to Elsabbagh et al. (2012) review, autism prevalence estimates ranged from 0.19/1000 (for the Autistic Disorder, AD) to 11.6/1000 (for the Pervasive Developmental Disorder, PDD)[3]. Two years later, Tsai (2014) updated Elsabbagh et al.'s review (2012) and reported only negligible differences that emerged in the median prevalence estimates. They were confirmed to be 1.32/1000 for AD and 6.19/1000 for PDD/ASD[4]. Table 1.1 summarizes and compares the results of Elsabbagh et al. (2012) and Tsai (2014) side by side.

[3] For context purposes, it is noted that the heterogeneity amongst the reviewed studies (e.g., diagnostic category, diagnostic criteria, age at prevalence evaluation, extent of the targeted geographical area, source of data on the diagnoses) and the fact that they were conducted within a time period of 50 years, are partially to be attributed with the autism prevalence range. Please refer to Elsabbagh et al. (2012) for the methodological details of the pertinent review.

[4] Please refer to Tsai's (2014) review for further methodological details of the pertinent study.

*Table 1.1 Summary of PDD prevalence estimates by Elsabbagh et al. (2012) and Tsai's (2014) reviews**

(Source: Chiarotti and Venerosi, 2020, p.3)

	Elsabbagh et al. (2012) review				**Tsai (2014) review**				
	N Studies	*Publication Year*	*Prevalence (/1000)*	*Median (/1000)*	*N Studies*	*Publication Year*	*Prevalence (/1000)*	*Median (/1000)*	*Papers in Tsai's review (2014) already included in Elsabbagh et al. (2012)*
Europe	14	2000-2011	3.0 to 11.6	6.16	21	2000-2012	3.0 to 12.3	6.19	66.7
Middle East	3	2007-2012	0.14 to 2.9	0.63	4	2007-2012	0.14 to 24.0	1.76	75.0
Asia	4	2008-2011	1.6 to 18.9	14.41	6	2008-2012	1.4 to 26.4	6.50	66.7
Australia and New Zealand	1	2004	-	3.92	2	2004-2009	2.4 to 3.9	3.15	50.0
North America	10	2001-2010	3.4 to 11.0	6.65	24	2001-2014	0.21 to 17.4	7.17	33.3
Central and South America	3	2008-2010	1.3 to 5.3	2.72	4	2008-2011	1.7 to 5.3	3.99	75.0
Africa	0	-	-	-	0	-	-	-	-

**Elsabbagh et al. (2012) presented the prevalence estimates for the diagnostic categories Autistic Disorder (AD) and Pervasive Developmental Disorder (PDD), which is the diagnostic category that evolved to ASD, passing from DSM-IV to DSM-5.*

Tsai's review (2014) used AD, and PDD or ASD; only the prevalence estimates for PDD (or ASD) are reported in Table 1.

Chiarotti and Venerosi (2020) reviewed epidemiology studies of worldwide prevalence estimates of Autism Spectrum Disorders since 2014. They provide an overview of those results per geographical area (Europe, the Middle East, Asia, North America, Australia, and New Zealand). The included studies yield different estimates of ASD prevalence among countries and even within the same country. Some points of interest regarding factors potentially affecting the different prevalence rates included, among others, the country/geographical area, the year of study, the data source, the participants' age, and the various risk factors for autism.

1.4.2 Autism prevalence estimates in Greece

Regarding autism prevalence in Greece, Thomaidis et al. (2020) investigated the estimated prevalence and age of autism (ASD) diagnosis. At that time, no large-scale prevalence study had been conducted before. The researchers collected aggregated data (gender and calendar year of ASD diagnosis) from the Centers for Educational and Counseling Support for children born in 2008 and 2009. According to their study, the overall autism prevalence was 1.15% (1.83% in males, 0.44% in females, with a ratio of 4.14:1). It ranged from 0.59% to 1.50% among 13 Greek regions, with five regions differing significantly in their prevalence rates (Table 1.2 and Figure 1.2). Lastly, the researchers argued that the study provides evidence-based results that can inform national and regional service planning and development.

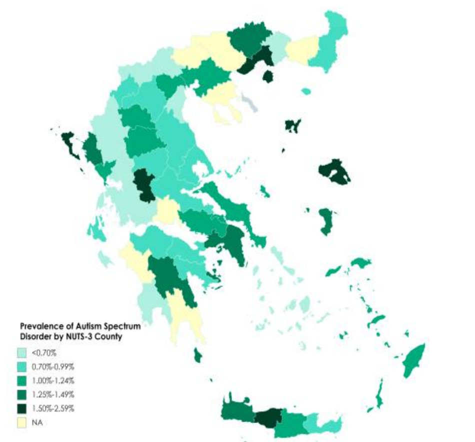


Figure 1.2 Prevalence of ASD
(*Source*: Thomaidis et al., 2020, p.7)

Table 1.2 Prevalence of Autism spectrum disorders (ASD) diagnosis in Greece in 2019 in children born in 2008 or 2009, by region. (*Source:* Thomaidis et al., 2020, p. 6)

Administrative region	**N***	**Autism Spectrum Disorders ASD**	
		N	**%**
North Aegean	3070	46	1.50
Attica	57,186	837	1.46
Ionian Islands	4606	64	1.39
Crete	15,052	203	1.35
Eastern Macedonia and Thrace	9920	121	1.22
Central Macedonia	31,072	317	1.02
Central Greece	9636	97	1.01
Thessaly	14,372	133	0.93
Peloponnese	9160	83	0.91
South Aegean	6835	58	0.85
Epirus	6107	48	0.79
Western Macedonia	5149	38	0.74
Western Greece	10,714	63	0.59

* Population of children in the areas served by participating centers whose year of birth was 2008 or 2009.

1.5 Etiology

The causation of autism remains not fully understood. Scientific knowledge on this matter continues to evolve as more research is conducted and new information becomes available. Autism is considered to be a heterogeneous disorder clinically and etiologically. Current evidence suggests that autism is a multifactorial disorder. Additionally, a complex interplay of genetic and environmental factors affects neurodevelopment (Figure 1.3). Thus, the suggestion is that environmental factors can result in the development of ASD in genetically predisposed individuals. Additionally, epigenetic factors are considered to play an important role and are also affected by environmental factors. The exact genetic, epigenetic, and environmental factors and mechanisms involved in the etiology of autism, which affect brain neurodevelopment and function in these individuals, remain under investigation.

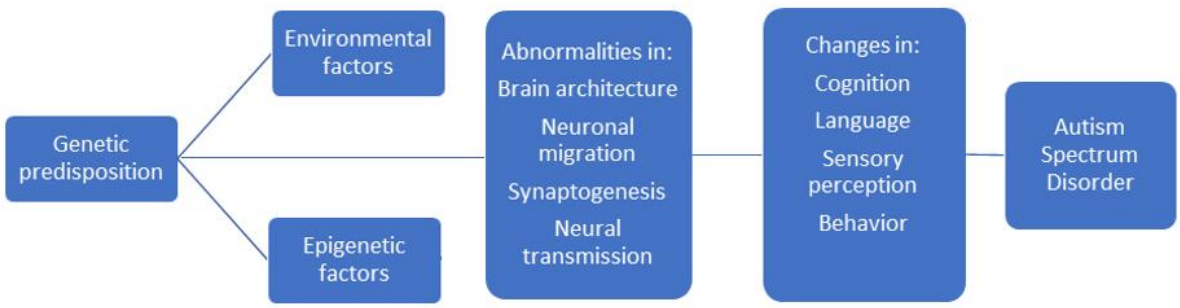


Figure 1.3 Genetic and environmental factors involved in autism etiopathogenesis.

(*Source:* Haroon, 2019, p.10)

1.5.1 Genetic factors

Autism's genetic base is complex and often not identifiable. A handful of cases involving single-gene mutations have been reported. It is likely that in most cases, common genetic variations work cumulatively and interactively to result in autism. There is also ongoing research regarding the advancing paternal and maternal age and their possible association with an increased risk for children with autism. Studies also examine the potential association between autism, genetic variations[5] and other mutations of candidate genes. At this time, several studies implicate hundreds of genes for autism. Nonetheless, larger sample sizes are needed to identify and gather more information on the candidate genes, their loci, associations, and common variants that lead to autism.

[5] For example: chromosomal abnormalities, copy number variations (CNVs), single-nucleotide polymorphisms (SNPs).

Regarding autism and comorbidity, there are some cases of genetic variations associated with autism and evidence/indications of pleiotropy[6]. An association with disorders such as schizophrenia and ADHD has been noted. Also, 5%-15% of cases with autism have other genetic disorders such as fragile X syndrome, tuberous sclerosis, and Smith-Lemli-Opitz syndrome.

Overall, there is a strong genetic basis and high heritability for autism. Families with a child with autism are at a greater risk of having a second child with autism. It is estimated that in dizygotic twins, there is a 10% chance for one of the two twins to have autism when the other one is affected. In monozygotic twins, the chances are as high as 82%-92%. Also, first-degree relatives of individuals with autism have a higher chance of exhibiting autism-like characteristics (e.g., mild deficits in social skills and language skills) without meeting the diagnostic criteria for autism[7].

1.5.2 Environmental factors

Besides the implication of genetic factors, environmental factors are also believed to contribute to the manifestation of autism in different developmental stages (Table 3). Environmental factors and their role in autism's etiology that are currently under investigation include, amongst other hormonal factors, gastrointestinal and immune system disorders/difficulties. It is noted that there are controversies in regard to some environmental factors, as their causality has either not been substantiated or has been overall discredited (Haroon, 2019).

[6] "Pleiotropy is defined as the phenomenon in which a single locus affects two or more distinct phenotypic traits." (Stearns, 2010, p. 767).

[7] These autism-like characteristics are often referred to as 'subthreshold traits', or 'broader autistic phenotype'" (Haroon, 2019).

Table 1.3 Some environmental factors thought to be involved in the etiology of autism.
(*Source:* Haroon, 2019, p. 10)

Developmental stage	Examples
Prenatal	Advanced parental age Maternal diabetes Exposure to teratogens (e.g., maternal; valproic acid, organophosphates) Infections (e.g., congenital rubella)
Perinatal	Birth asphyxia Prematurity Low birth weight
Postnatal	Hypoxia Autoimmune disease Postnatal infections Mercury and other environmental pollutants

1.6 Interventions for autism for children and adults

There is a plethora of pharmacological and non-pharmacological/behavioral interventions available nowadays for the treatment of autism and its symptoms. Pharmacological interventions are supplementary to non-pharmacological interventions. While some interventions are based on trustworthy research data and yield effective results, others lack sound evidence (Haroon, 2019).

Overall, autism interventions aim not to cure the disorder but to manage its symptoms and pertinent behaviors in a safe, unbiased, valid, and patient-centered manner. According to the Institute of Medicine of the USA (2001), there are six key axes in quality care: safety, timeliness, effectiveness, efficiency, equity, and patient-centeredness. Regarding autism, both pharmacological and non-pharmacological treatments need to adhere to the aforementioned quality parameters (Haroon, 2019). When it comes to evidence-based medicine and clinical guidelines, recommendations are made based on data from studies available and the hierarchy of the evidence pyramid. However, when data/evidence is not available, then decisions and recommendations are made based on expert opinion, i.e., the experience of a group of experts using informal (e.g., Guideline Development Group) or formal consensus methodologies (e.g., Delphi panel/study) (Haroon, 2019).

1.6.1 Behavioral and pharmacological interventions in children

Behavioral (non-pharmacological) interventions can be as simple as being carried by parents (‘parent-mediated interventions’) to more complex ones that professionals carry. The general recommendation is to consider behavioral interventions before pharmacological treatment. The latter is considered to be part of the overall treatment approach (Haroon, 2019). Table 1.4a includes behavioral intervention guidelines as issued by SIGN[8] in 2016, indicating interventions

[8] The Scottish Intercollegiate Guidelines Network (SIGN) produce evidence-based, collaboratively developed clinical guidelines (https://www.sign.ac.uk/)

that should be considered (**), may be considered (*), or a recommendation could not be made (due to study quality or limited benefits (Haroon, 2019, p. 4). On the other hand, when pharmacological treatments (Table 1.4b, Haroon, 2019, p.4) for children with autism are deemed appropriate, they are used in conjunction with behavioral interventions and for the management of comorbid psychiatric and neurodevelopmental disorders, medical conditions (e.g., epilepsy), and severe behaviors (Haroon, 2019).

<table>
<tr><th colspan="3">Table 1.4 Behavioral and pharmacological interventions for autism</th></tr>
<tr><th>Table 1.4a Behavioral interventions for autism
(Source: Haroon, 2019, p.70)</th><th colspan="2">Table 1.4b Pharmacological interventions for autism
(Source: Haroon, 2019, p.71)</th></tr>
<tr><td rowspan="2">➲ Parent mediated interventions**
➲ Parent and clinician led interventions
➲ Visual supports
➲ Picture Exchange Communication System (PECS)**
➲ Environmental visual supports**
➲ Social skill groups**
➲ Computer based interventions**
➲ Early Intensive Behavioral Intervention
➲ Support from staff trained in Applied Behavioral Analysis technology **
➲ Treatment and Education of Autistic and related Communication handicapped Children (TEACCH)
➲ Social Stories
➲ Cognitive behavioral therapy*
➲ Auditory Integration Training</td><td>➲ Second generation antipsychotics (e.g., aripiprazole)</td><td>Can help in the short term (8 weeks) to reduce irritability and hyperactivity. Associated with significant side effects which prescribers should be aware of and communicate to carers/patients. Effectiveness should be reviewed after 3-4 weeks and medication stopped at 6 weeks if not effective.</td></tr>
<tr><td>➲ Medication for ADHD - Methylphenidate</td><td>Medication for ADHD can be very effective and there is evidence to support the use of methylphenidate in children with ADHD-type symptoms and autism although it is limited.
The evidence for treating and young persons with other drugs used to treat ADHD is less well-founded and should be considered with</td></tr>
</table>

➲ Sensory Integration Training and occupational therapy* ➲ Music therapy ➲ Behavioral therapy for sleep**		reference to national guidance, and the BNF by those experienced with their use
	➲ Antidepressants Selective serotonin reuptake inhibitors	Useful in children and young persons with coexisting conditions such as depression.
	➲ Melatonin	To help with sleep alongside a consistent bedtime routine and sleep hygiene. This can be considered in children and young persons where there has been an insufficient improvement after behavioral interventions. Medication should be commenced in consultation with a pediatrician or psychiatrist with the relevant expertise and its use should be appropriately monitored.

1.6.2 Behavioral and pharmacological interventions for adults

Behavioral (i.e., non-pharmacological) interventions in adults target an array of deficits in areas such as communication, social skills, behavior, psychiatric disorders, daily living, and vocational skills. Many of these interventions were primarily developed for children. When studied in adults, small sample sizes and at times questionable quality can affect validity and reliability (Haroon, 2019). Regarding pharmacological interventions, as with children with autism, their use is something to be taken into consideration for the treatment of comorbid disorders in adults with autism. Nonetheless, it is noted that there is limited evidence regarding the use of a wide range of medications, which should be used “not to address the core features of autism but for challenging behaviors where behavioral treatments have not worked” (Haroon, 2019, p.71).

1.7 ICT Interventions in Autism

1.7.1 Computer-based systems

Information and Communication Technology (ICT) is among the most well-known and studied intervention approaches for supporting individuals with autism. Computers and digital technology, in general, are considered effective and beneficial for enhancing individuals’ communication, social, and learning skills and needs. Their benefits appear to outweigh the cost, which is higher compared to traditional and non-electronic methods (Silton, 2014).

Characteristics attributed to the effective and beneficial use of technology and computers by individuals with autism include (Silton, 2014):

- being predictable and familiar,
- allowing users to work at their own pace,
- administered tasks can be consistently repeated,
- individualized and structured learning,
- utilization of visual learning (considered a preferred means of learning),

- minimization of social interaction challenges and complexities,
- being readily available, affordable, and accessible.

In the vein of the benefits offered by computers to individuals with autism, Murray (1997) refers to several of them, including setting boundaries, stimulus control, joint attention, focusing on learning material, restrictive content, safety, flexibility, adaptability, and predictability. These attributes appear to be commensurate with strengths and skills demonstrated by individuals with autism (Silton, 2014). They also have the potential to support individuals' communication skills, social skills, and overall learning, thereby promoting their independence and self-confidence (Charitos et al., 2000; Tseng and Do, 2011; Silton, 2014). Types of computer technology for autism that are considered effective and beneficial include: computer games and software programs; touch screens; videotaping; e-books; interface devices; switches; joysticks; trackballs; pointing devices; alternate keyboards; voice recognition, and speech synthesis/screen reading (Wisconsin Assistive Technology Initiative, 2009).

1.7.2 Virtual Reality technologies and autism

As previously mentioned, computers offer predictable, reinforcing, and socially friendly routines with straightforward expectations (Murray, 1997; Schmidt and Schmidt, 2008; Silton, 2014). Researchers extend the attributes and benefits observed in the use of computers to the use of virtual (collaborative) environments for individuals with autism. It is argued that virtual environments can support the development of social-emotional skills. They allow and are forgiving of users' errors, unlike real-life social interactions. Additional advantages of using virtual environments in autism include their adaptability and customization to meet each individual's needs (Schmidt and Schmidt, 2008). Overall, several studies highlight the learning potential of using virtual environments in autism. At the same time, they also highlight design issues (Millen et al., 2010; Cobb et al., 2010) and the need for human-computer interaction (HCI) guidelines (e.g., structure, sensory stimulation, user-centered controllability). They suggest that this is necessary to establish clear design principles for developing virtual environments for individuals with autism (Grandin, 2002; Van Rijn and Stappers, 2008; Millen et al., 2010).

1.8 Summary

- Autism is a neurodevelopmental disorder with a heterogeneous clinical profile. It includes manifestations of social communication and interaction difficulties, accompanied by repetitive behavioral patterns and activities that vary in severity.
- Autism is a lifelong condition that can affect several aspects of an individual’s life.
- There is an array of intervention strategies and approaches for the various areas affected, as well as levels and degrees of symptoms’ severity. Although autism is a lifelong disorder that cannot be ‘cured’, there are early interventions and treatments (pharmacological and non-pharmacological) that can help.
- Positive treatment results can also deal with symptoms of comorbidity when co-occurring disorders have been identified.

Chapter 2

VIRTUAL REALITY

2.1 Introduction

Virtual Reality applications are increasingly used in various disciplines. They are considered useful, applicable, technologically advanced, and popular (Bamodu and Ye, 2013). New technologies and their continuous evolvement, as well as advances, offer new and improved media. Virtual Reality is among the newest ones. It helps people express themselves, communicate, experiment, and find practical solutions to both simple and complex issues (Sherman and Craig, 2018).

2.2 Immersive technology

Under the umbrella term 'immersive technology', several different technologies exist, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) (Handa, Aul, and Bajaj, 2012) (Table 2.1). There are various definitions of immersive technology, depending on the perspective of the researcher(s) defining it. Thus, immersive technology can be defined on the proprietary basis that it offers its users a unique and high-quality/quantity of sensory information (Slater, 2009).

2.3 Forms of Reality: virtuality continuum

According to Jerald (2016), Reality can range and take many forms. In 1994, Milgram and Kishino first proposed their multi-referenced reality-virtuality continuum that describes the concept and scope of immersive technology (Figure 2.1) (Jerald, 2016; Suh and Prophet, 2018). The concepts depicted in the continuum are (Jerald, 2016, p. 30; Milgram and Kishino, 1994):

Real environment refers to the world in which we live, perceive, interact with, and function in. Knowing and understanding its traits is the basis for recreating realistic and functional virtual experiences.

Augmented Reality (AR) incorporates digital elements into the real world, allowing the human brain to experience this as seamlessly as possible.

Augmented virtuality (AV) captures the real world and translates it to virtual Reality (e.g., immersive films). Users can perceive these environments from one or any perspective, whereas in some cases, they can even move freely within them.

Virtual environments aim to fully engage their users in realistic yet artificial experiences of digital worlds that convey a sense of presence and 'being there' (Jerald, 2016, p. 30; Milgram and Kishino, 1994).

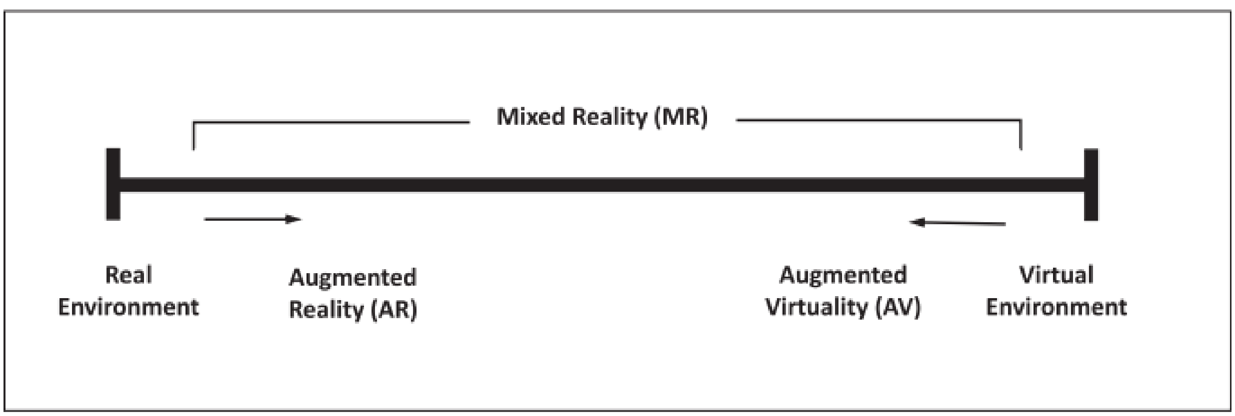


Figure 2.1 The reality-virtuality continuum

(*Source*: Suh and Prophet, 2018, p.78; Jerald, 2016, p. 30)

Based on the depicted virtuality continuum (Suh & Prophet, 2018), in the general area of Mixed Reality (MR), real environments (Reality) and virtual environments (Virtual Reality) are positioned at opposite ends of the MR spectrum. AR and AV (Augmented Virtuality) are areas within the general field of MR, leaning respectively towards reality and virtuality. AR marries real and virtual worlds, whereas VR simulates real worlds over which navigating users have control (Zeng and Richardson, 2016). Both technologies lead to different degrees of immersion and MR (Di Serio, Ibáñez, and Kloos, 2013). Additionally, it is noted that in the reality-virtuality continuum, AV and VR are often used interchangeably when referring to real objects added in both cases (Hsiao, Chen, and Huang, 2012).

It is noted that in the reality-virtuality continuum, VR can be immersive or non-immersive. In non-immersive VR, the virtual content is displayed on a computer screen (i.e., without immersion amplifying equipment) while users interact via conventional interfaces (e.g., keyboard, mouse). Examples of non-immersive VR are Web-based virtual environments, such as Second Life and Minecraft (Zeng and Richardson, 2016). On the other hand, immersive VR utilizes complex tracking systems (e.g., head-mounted displays). AR, positioned on the opposite side of VR in the reality-virtuality continuum, blends real and digital images, offering users a real-time and digitally enriched reality experience (Suh and Prophet, 2018).

2.4 Definition of Virtual Reality

Virtual Reality can have different interpretations, meanings, and definitions based on the field of origin of its definers. Webster's New Universal Unabridged Dictionary (1989) defines virtual as "being in essence or effect, but not in fact, with this verbiage being used in various fields loosely or more intentionally (e.g., in computing, virtual memory for extended RAM). Defining the term 'reality' is no less complicated and can even lead to a more philosophical approach to its definition. In a simplistic yet functional view, reality "is a place that exists and that we can experience". Webster's definition of reality is that it is "the state or quality of being real. Something that exists independently of ideas concerning it. Something that constitutes a real or actual thing as distinguished from something that is merely apparent." (Sherman and Craig, 2003, p.6).

VR is often used to refer to fictional environments that can be digital or not. Craig, William, and Jeffrey's (2009) definition of VR is of "a medium composed of interactive computer simulations […] giving the feeling of being immersed […]". Respectively, Bamodu and Ye (2013) refer to Zhuang and Wang's definition of VR as "a high end Human-Machine Interface, that combine technologies such as computer graphics, image processing, pattern recognition, artificial intelligence, networking, sound systems and others to produce computer simulation and interaction, which gives the feeling of being present through multiple synthetic feedback sent to sensorial channels like virtual, aural, haptic and others". Other terms used interchangeably with VR include Virtual Environment, Artificial Reality, Virtual Worlds, Artificial Worlds, and Cyberspace (Bamodu and Ye, 2013, p. 0921).

In 1965, Ivan Sutherland, well-known for creating one of the first VR systems in the 60s, ambitiously said that: "The ultimate display would, of course, be a room, within which the computer can control the existence of matter. A chair displayed in such a room would be suitable for sitting in. Handcuffs displayed in such a room would be confined, and a bullet displayed in such a room would be fatal" (Milgram, et al., 1995, p.283).

Lastly, Kim (2005) defined virtual Reality as "a field of study that aims to create a system that provides a synthetic experience for its user(s). The experience is dubbed “synthetic,” “illusory,” or “virtual” because the sensory stimulation to the user is simulated and generated by the “system”. For all practical purposes, the system typically consists of various types of displays for delivering stimulation, sensors to detect user actions, and a computer that processes the user's actions and generates the display output. To simulate and generate virtual experiences, developers often build a computer model, also known as “virtual worlds” or “virtual environments (VE),” which are, for instance, spatially organized computational objects (aptly called the virtual objects), presented to the user through various sensory display systems such as the monitor, sound speakers, and force feedback devices. One important component of a successful VR system is the provision of interaction, to allow the user not just to feel a certain sensation, but also to change and affect the virtual world in some way" (p. 3). Figure 2.2 illustrates the fundamental components and principles of a VR system (Kim, 2005).

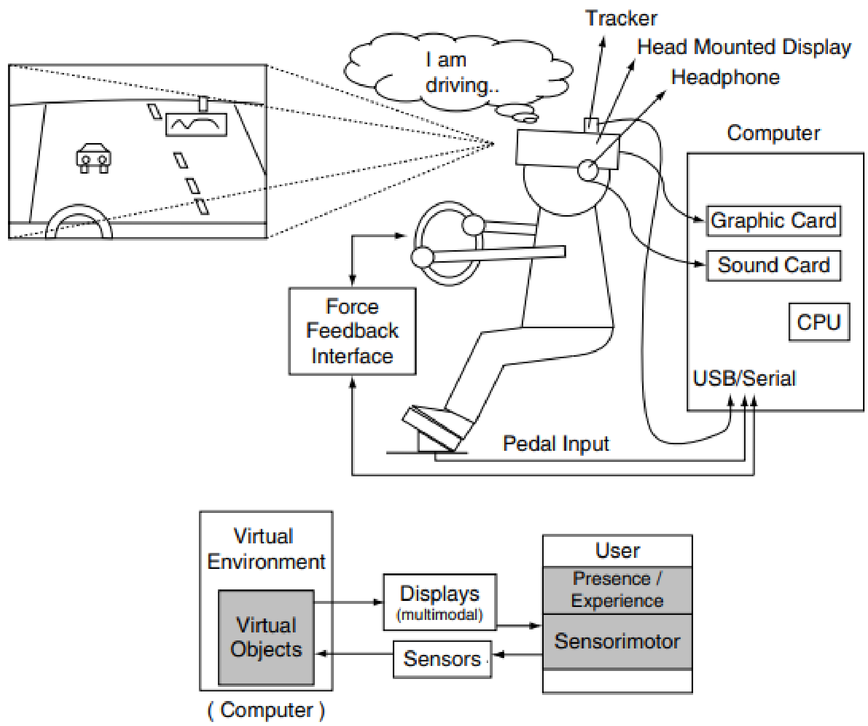


Figure 2.2 Virtual driving simulation including a simplified depiction of the VR system. (*Source:* Kim, 2005, p. 4).

2.5 Augmented Reality

Although the term Augmented Reality (AR) is frequently used in relevant literature, its definition has been inconsistent. In a broader approach, AR has been defined as "augmenting natural feedback to the operator with simulated cues" (Das, 1994). In contrast, a narrower definition is the one of "a form of virtual reality where the participant's head-mounted display is transparent, allowing a clear view of the real world." (Milgram et al., 1995, p.283). Azuma (1997) defined AR as the technology that enriches the real world with digital content as 3D digital representations and real-life objects interact in real-time.

Augmented Reality embeds digital stimuli (e.g., visual, audio, haptic) into real-life environments, enabling users to comprehend the displayed information as a whole. Examples of such applications include medicine (e.g., surgery), industrial, defense, tourism, advertising fields, and even in mobile phones (e.g., location applications that provide information about nearby amenities (Mihelj, Novak, and Beguvs, 2014; Alqahtani, Daghestani, and Ibrahim, 2017).

Regarding the relationship between Augmented Reality (AR) and Virtual Reality (VR), VR environments provide users with a fully digital, immersive experience of worlds that recreate proprietary real-life environments, variations of them, or entirely new worlds with their own properties and laws. On the other hand, real worlds are situated on the opposite side of the reality-virtuality continuum, as they abide by and are at the same time constrained by physical laws. On the left side of the continuum, the referenced environments encompass anything observed in the real world, whether directly or indirectly (e.g., windows, videos). At the right of the continuum, the referenced environments are only virtual and are displayed through immersive digital simulations. According to the continuum, Mixed Reality (MR) is situated in the middle, combining the real and virtual worlds in a single display. Thus, overall, VR and AR can be considered related concepts that complement each other (Milgram et al., 1995).

2.6 History of VR

Creating illusions, conveying new or existing worlds, and capturing imaginations have been a part of human history since its early beginnings, from cave drawings to the civilizations of the Egyptians, Romans, Greeks, the Middle Ages, and modern times (Hopkins 1897; Jerald 2016).

2.6.1 The 1800s

In 1832, Sir Charles Wheatstone invented the stereoscope, a precursor to today's stereoscopic 3D TV static (Gregory, 1997; Jerald, 2016). It used 45° angled mirrors that reflected images into the eyes from both sides (Figure 2.3). Later, after inventing the kaleidoscope, David Brewster

(Brewster, 1856; Jerald, 2016) created a smaller and more practical version of the stereoscope (Figure 2.4). This handheld version of the stereoscope utilized lenses, and its design is conceptually similar to that used in the 1939 View-Master and the 2014 Google Cardboard. In 1895, the Haunted Swing, a 360° VR-type display, was exhibited in San Francisco, CA. It was a room with a big enough swing to fit 40 people. It oscillated, giving its users an elevator-like motion. In fact, the swing would actually stay still, whereas it would be the room that was moving. This gave users a sense of motion, if not of motion sickness (Jerald, 2016). It was also the same year that a virtual train was used in a short film ("L'arrivée d'un train en gare de la Ciotat"), creating a sense that it was heading towards the theater's viewers. Although reports of viewers screaming and running away from the room were not verified, the type of excitement and fear associated with that technology seems to be similar to the common perception of today's VR (Jerald, 2016).

Figure 2.3 Charles Wheatstone's stereoscope (*Source:* Jerald, 2016, p. 17)

Figure 2.4 David Brewster's stereoscope (*Source:* UK Science Museum Group - Collection (*Source:* https://collection.sciencemuseumgroup.org.uk/objects/co8085510/brewster-pattern-stereoscope-stereoscope)

2.6.2 The 1900s

The first head-tracking HMD and telepresence system was developed in 1961 by the Philco Corporation. In 1962, IBM patented the first glove input device; it was later used in VR. In 1965, Tom Fumes and his team at the Wright-Patterson Air Force Base made head-mounted displays for pilots (Jerald, 2016). At the same time, Ivan Sutherland was the first to use a head-mounted display with head tracking and computer-generated imagery (Oakes, 2007; Jerald, 2016); the system was called the Sword of Damocles (Jerald, 2016).

Following Sutherland's footsteps, Dr. Brooks founded a new research program in interactive graphics at the University of North Carolina at Chapel Hill. The team developed Grope-III, a system for the visual simulation of molecular interactions and providing "haptic" (tactile) feedback for the physical binding forces between molecules. The team continues its work, developing various VR systems for applications in radiology, ultrasound imaging, architecture, and surgery (https://www.britannica.com/technology/virtual-reality/Education-and-training#ref884324; Jerald, 2016).

In 1982, the Atari Research team explored new interactive and computerized ways for commercialized entertainment VR systems. In 1995, Scott Fisher and other NASA researchers designed the Virtual Visual Environment Display (VIVED), the first commercial stereoscopic head-tracked HMO. In 1992, Scott Foster and Elizabeth Wenzel developed Convolvotron, an affordable and HMD system with localized 3D sounds that revolutionized the commercial VR industry (Foster and Wenzel, 1992; Jerald, 2016). Another system that was subsequently developed was the VIEW (Virtual Interface Environment Workstation), a head-mounted stereoscopic display system that allows users to immerse themselves in and interact with a real or digital environment. (https://www.nasa.gov/ames/spinoff/new_continent_of_ideas/#:~:text=The%20Virtual%20Interface%20Environment%20Workstation%20(VIEW)%20is%20a%20head%2D,environment%20and%20interact%20with%20it; Jerald, 2016).

In 1985, Zimmerman and Lanier, who coined the term “virtual reality”, started VPL Research (i.e., Visual Programming Language). VPL Research made commercial HMDs, VR gloves, software, and the Dataglove for NASA. The latter was able to provide visual and tactile feedback to the user while being able to measure fingers’ bending (Zimmerman et al., 1987; Jerald, 2016). In the 1900s, VR focused on the research market and entertainment, reaching its peak in 1996. It later gradually declined with several VR companies shutting down by 1998 (Jerald, 2016)**.**

2.6.3 The 2000s

In the 2000s, although getting less media attention, VR continued to enjoy rigorous research in the corporate, government, academic, and military fields. Its design became more user-centered, and formal evaluations were often performed. In 2006, the Wide5, a wide-field view HM-D, was created, filling the gap in this type of equipment that had previously been missing from commercial use. In 2012, the low-cost Field of View To Go (FOV2GO) was demoed, awarded, and is considered the precursor to most of today's consumer HMDs. Around that time, Oculus VR was founded, marking the beginning of a new chapter in VR breakthroughs and development (Jerald, 2016).

2.7 VR technologies: systems and types

As previously mentioned, and in accordance with Milgram and Kishino’s (1994) virtuality continuum, Reality can take various forms (Jerald, 2016). According to Alqahtani, Daghestani, and Ibrahim, (2017), there are six main fields of VR applications found amongst others in literature: a) medicine, b) engineering and architecture, c) data visualization, d) designing, and e) construction monitoring.

2.7.1 VR systems

Jerald (2016) states the following regarding reality systems (p.30): “A reality system is the hardware and operating system that full sensory experiences are built upon. The reality system’s job is to effectively communicate the application content to and from the user in an intuitive way, as if the user is interacting with the real world. Humans and computers do not speak the same language, so the reality system must act as a translator or intermediary between them (note that the reality system also includes the computer). It is the VR creator's obligation to integrate content with the system, so the intermediary is transparent, and to ensure objects and system behaviors are consistent with the intended experience. Ideally, the technology will not be perceived so that the users forget about the interface and experience the artificial Reality as if it is real."

2.7.2 VR system types and hardware

There are several categorization approaches and views of VR systems (Bamodu and Ye, 2013). VR systems are often categorized based on their level of immersion and the equipment used to achieve that (Alqahtani, Daghestani, and Ibrahim, 2017). A classification frequently seen in literature is based on immersion and the interfaces/components of the VR system. It is that of three main types of VR systems: i) non-immersive, ii) (fully) immersive, and iii) semi-immersive (Bamodu and Ye, 2013; Alqahtani, Daghestani, and Ibrahim, 2017) (Figure 2.5). Each one of the aforementioned types is described in more detail below.

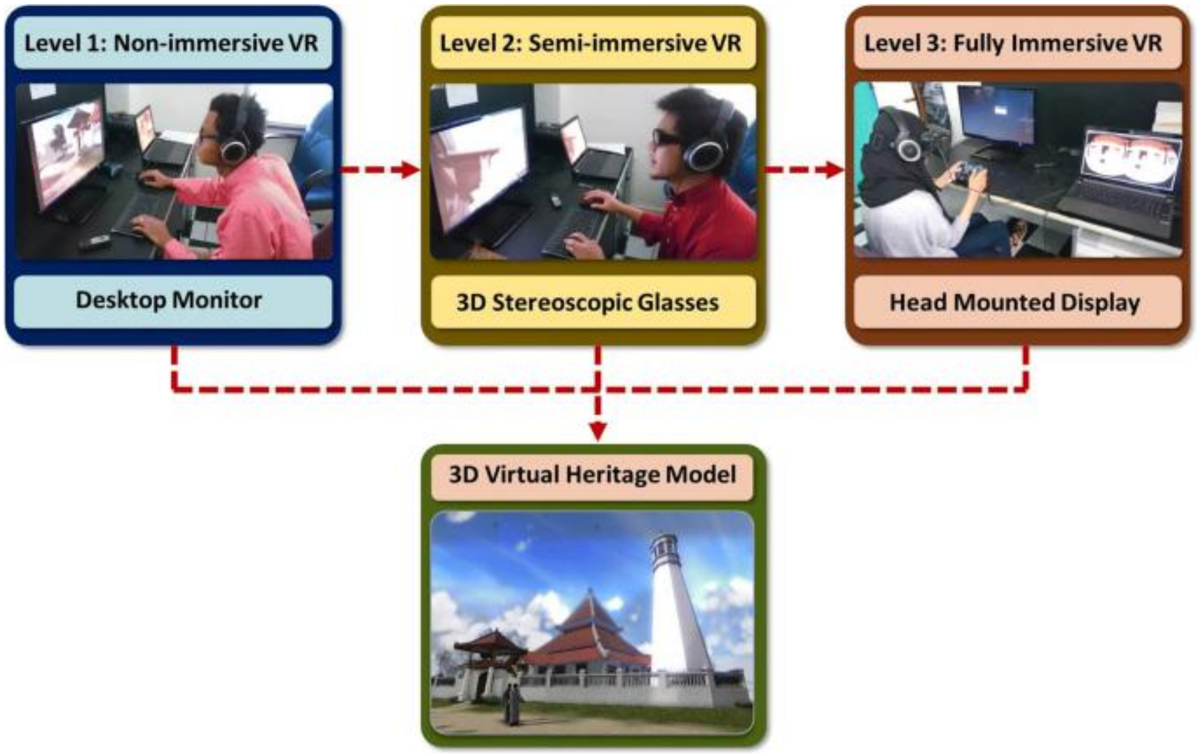


Figure 2.5 VR systems (*Source:* Ghani, Rafi, and Woods, 2019, 1-12).

2.7.2.1 Non-immersive VR systems

Non-immersive systems, often referred to as Desktop VR and occasionally Window on World (WoW) systems (Mandal, 2013; Sala, 2006). They use simple and affordable components (such as stereo display monitors, glasses, space balls, keyboards, and HMDs) through which their users interact with the displayed 3D environment. They are the least immersive systems and are used for modeling and CAD systems. Examples of such VR systems include the Desktop VR system, the Fish Tank, and the Window on World system (Bamodu and Ye, 2013). Although the level of presence, immersion, and interaction in these systems is low, the graphic quality, user comfort, convenience, and cost are overall satisfactory (Cox, 2003; Cartwright and Peterson, 2007). Non-immersive VR utilizes basic components, and pertinent applications are employed in school settings (Bamodu and Ye, 2013) and video games. Overall, screen-based non-immersive systems offer 3D displays of virtual worlds that are blended into real-life environments. Additionally, other Desktop VR systems, such as virtual worlds, are utilized in education to support users' learning and understanding of educational content. Virtual worlds provide interactions among their users, and more specifically, among their avatars (Daghestani, 2013).

2.7.2.2 Semi-immersive VR systems

Semi-immersive VR systems, also referred to as hybrid (Dani and Rajit, 1998; Bamodu and Ye, 2013), utilize basic components similar to those found in a desktop VR system (Bamodu and Ye, 2013). Applications and examples of such systems are the CAVE (Cave Automatic Virtual Environment) and the driving simulator (Blackedge, Barrett, and Coyle, 2010; Bamodu and Ye, 2013). As previously mentioned, semi-immersive VR systems are hybrid systems that capitalize on the combined ease of Desktop VR systems and the high immersive and interactive nature of devices such as the Data Gloves (Bamodu and Ye, 2013). They use tracking sensors, user interfaces, and input devices (e.g., mouse, keyboard, interaction styles, glasses, and joystick (Daghestani, 2013) that allow users to interact with the displayed digital environments (e.g., text, graphs, and images) and its embedded real-life attributes (Mihelj, Novak, and Beguvs, 2014; Alqahtani, Daghestani, and Ibrahim, 2017).

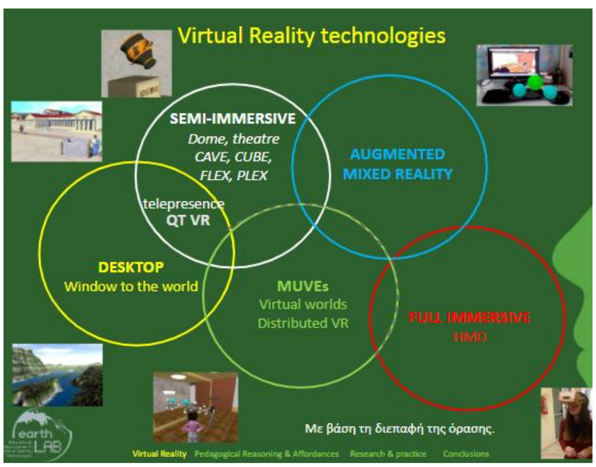
2.7.2.3 (Fully) Immersive VR systems

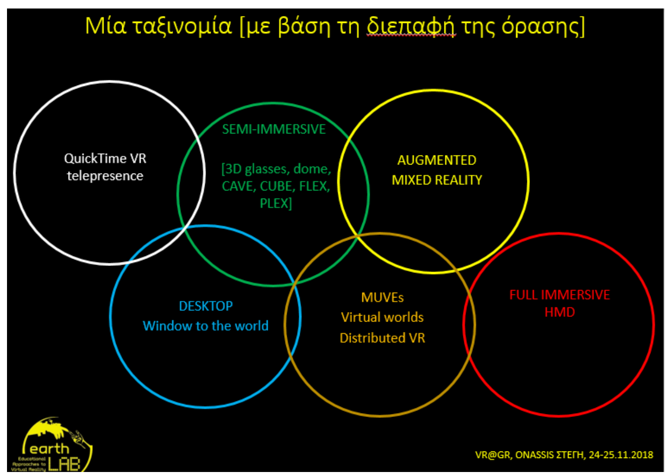
Immersive or fully immersive VR systems use sophisticated and expensive components (such as HMD, tracking devices, and data gloves). The equipment eliminates all external stimuli, allowing users to be fully immersed in the digital 3D environment (Bamodu and Ye, 2013). They track users' head movements and adjust their view of the virtual world (Cox, 2003; Mihelj, Novak, and Beguvs, 2014), offering a fully immersive experience. Some of the disadvantages of this type of VR system relate to the generated images and the environmental burden of the simulators (Daghestani, 2013).

2.7.2.4 Distributed-VR

This new category of VR systems, also known as Network VR, utilizes the internet and other types of networks to connect people in virtual worlds, thereby overcoming distance and location restrictions. Applications of such VR systems include the SIMNET, a real-time combat training simulation by the US military (Burdea and Philippe, 2003; Bamodu and Ye, 2013). Lastly, open-source software packages such as "Open Simulator, and Open Croquet" are used for the development of virtual worlds (Kaplan and Yankelovich, 2011; Alqahtani, Daghestani, and Ibrahim, 2017). A taxonomy of VR systems and types, based on visual interface (Mikropoulos, 2016, 2018), is also depicted in the figure below (Figure 2.6).

Figure 2.6 Schematic representation and classification of VR technologies/systems based on visual interface





Virtual Reality technologies

(*Source*: Mikropoulos, 2016, slide #18 - used with author's/presenter's permission, Mikropoulos T.A. on 1/15/2021).

Virtual Reality technologies (updated)

A taxonomy based on a visual interface

(*Source*: Mikropoulos, 2018, slide #10 - used with author's/presenter's permission, Mikropoulos T.A. on 3/11/2021).

2.8 Affordances: VR affordances and learning affordances

2.8.1 Affordances

James Gibson (1977, 1979) first proposed the term "affordances" to indicate the possible actions "provided to the actor by the environment". Originally stemming from ecological psychology, the term was later utilized in design by Norman (1988) and subsequently in interaction design and Human-Computer Interaction (HCI). The reasoning behind this was that designers were particularly interested in clearly and efficiently indicating product usage (intuitive design), for example, using any car door handle correctly and effortlessly without having prior knowledge, experience, and training about its use. Kaptelinin (2005) further notes that according to Norman (1998), "Affordances provide strong clues to the operations of things. Plates are for pushing. Knobs are for turning. Slots are for inserting things into. Balls are for throwing or bouncing. When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction needed." Following their applications in HCI and interaction design, affordances quickly gained ground in research, education, and interactive technologies. Designers' target was to design everyday items in an "intuitive" and "usable" manner (Kaptelinin, 2005).

As Kaptelinin (2005) notes, affordances are fundamental concepts and principles in HCI (e.g., Rogers et al., 2011), and their use extends beyond tangible and real-life objects. It expands in graphic user interfaces (e.g., clickable buttons) that provide created objects with a more flexible approach to their visual elements, i.e., in Norman's (1998) words, "strong visual clues to the operation of things". Like many concepts of HCI, affordances have their own fair share of different interpretations, definitions, and controversies (Kaptelinin, 2005).

Virtual Reality technologies possess unique attributes for pedagogical applications. 3D spatial representations (virtual environments and virtual worlds) of real-life objects and conditions, use their unique attributes, i.e., affordances (e.g., autonomy, users' representation through avatars, multisensory intuitive and real time interaction, first-order experiences, size in space and time, immersion, transduction and reification, and presence (Mikropoulos and Natsis, 2011) for students' overall learning and educational benefit. Thus, since these affordances have the potential to support users' learning, they can be considered as learning affordances (Norman, 1988). The learning affordances of VR can be classified in the following categories: free navigation, creation, modeling and simulation, multichannel communication, collaboration and cooperation, content presentation and delivery (Mikropoulos, 2016).

2.8.2 VR affordances

Mikropoulos and Natsis (2011) provide a thorough list of VR's (and MUVEs') affordances that also contribute to learning, i.e. 1) "multisensory intuitive and real-time interaction"; 2) "immersion"; 3) "presence"; 4) "avatars"; 5) "first-person user point of view"; 6) "autonomy"; 7) "natural semantics for the representation of objects and facts inside the virtual environments and worlds"; 8) "first-order experiences"; 9) "size in space and time"; 10) "transduction and reification" (Mikropoulos and Natsis, 2011; Mantziou, Papachristos, and Mikropoulos, 2018). Five of the most prominent and key characteristics of VR affordances are described below: presence, immersion, avatars, multisensory, intuitive, and real-time interaction, and first-person user point of view.

2.8.2.1 Presence

Presence is the "sense of being there" that users of virtual Reality have while being 'transformed in an alternative world as a separate entity' (Mikropoulos and Natsis, 2011, p.770). Since the 1990s and continuing into the 2000s (Bricken, 1990; Winn and Windschitl, 2000; Mikropoulos and Natsis, 2011), relevant literature has provided evidence that virtual environments and presence support learning and the learning process overall. Regarding presence, the "sense of being there" reinforces users' "first-hand" experiences and interactions with the digital (or not) world (Winn and Windschitl, 2000; Winn, 1993; Mikropoulos and Natsis, 2011).

2.8.2.2 Immersion

Immersion is a distinguishing feature of VR that engages almost all of the user's sensory pathways (besides taste) through various peripheral devices. Nowadays, the cost and practicality of the immersive systems make them consumer and school-friendly. Furthermore, the literature supports the notion that the use of immersive environments can be beneficial for learning and provide an overall positive experience, as reported by users (Mikropoulos and Natsis, 2011). Regarding learning, constructivism appears to be the educational learning theory best suited for immersive Educational Virtual Environments (EVEs), although further studies are needed in this area (Dede, 2009; Mikropoulos and Natsis, 2011).

2.8.2.3 Presence versus immersion

Presence and immersion are often used interchangeably in research and literature. However, they are not the same. According to Bailenson et al. (2008), "an immersive virtual environment (IVE) is one that perceptually surrounds the user, increasing his or her sense of presence or actually being within it." (p. 104). Mikropoulos and Natsis (2011) offer this definition of immersion, which is similar to the one made by Dede (2009): "immersion is a result of the involvement of more than one perceptual channel and not only a subjective impression" (Mikropoulos and Natsis, 2011, p.777).

2.8.2.4 Avatars

VR technology users can collaborate, construct, negotiate, and socialize for knowledge together, using avatars. Research examples from the aforementioned and with EVEs include avatars that communicate with users verbally and non-verbally (e.g., in English and in American Sign English, ASL) (Adamo-Villani and Wilbur, 2008); student's avatars sharing information with other digital characters to save fish (Barab et al., 2007); avatars helping students to interact with the digital environment and perform tasks (Hokanson et al, 2008); avatars collaborating with users in order to navigate and perform home tasks in an ancient city (Mikropoulos, 2006; Mikropoulos and

Strouboulis, 2004), and student-users “talking” what virtual agents in order to collect geographical information (Tuzun et al., 2009). Regarding other digital environments and avatars, in the MUVE River City, student users communicate with residents’ avatars to collect information for their research (Ketelhut, 2007; Nelson, 2007; Nelson and Ketelhut, 2008). Additionally, in the PUPPET world, users’ avatars (children-farmers) interact with animal avatars as they work to maintain the digital farm (Marshall et al., 2005; Mikropoulos and Natsis, 2011).

2.8.2.5 Other VR affordances

Other important VR affordances include the multisensory, intuitive and real-time interaction as well as 1st person point of view. The multisensory interaction VR affordance refers to the use of different sensory modalities, such as images, voices/sounds, hand motions, gestures, and even smells that can create experiences and convey ideas through the multisensory interface between the human (user) and the virtual reality (VR) based system (Chu, Dani, and Gadh, 1997). Intuitive interaction is fast (Salk, 1983) and uses knowledge from previous experiences (Desai, Blackler, and Popovic, 2016). It is considered non-conscious and thus does not involve conscious reasoning (Bastick, 2003; Desai, Blackler, and Popovic, 2016). However, it involves actions and decisions which cannot be explained or verbalized (Blackler et al., 2010; Desai, Blackler, and Popovic, 2016). Lastly, intuition is associated with ‘high degrees of certainty’, ‘confidence,’ and ‘expectation’ concerning the correct and appropriate use of a feature (Bastick, 2003; Hammond, 1993; Woolhouse and Bayne, 2000; Desai, Blackler, and Popovic, 2016). Real-time interaction refers to the interaction between the virtual content and the user, i.e., the actual time during which a process or event occurs and is available “immediately” as feedback (Cho, Jung, and Jee, 2017). Lastly, 1st user point of view refers to the users’ viewpoint and first-person perspective (1PP). It can potentially enable more accurate interactions, as it may induce a sense of embodiment toward a virtual body, particularly in terms of self-location (i.e., determining the volume in space where the user feels located) and ownership (i.e., one’s self-attribution of a body) (Gorisse et al., 2017).

2.8.3 VR learning affordances

Mantziou, Papachristos, and Mikropoulos (2018) offer a comprehensive collection of definitions for the term ‘affordances,’ and its extension in learning and education, i.e., ‘learning affordances. ’ In 2002, “[...] “Kirschner introduced the term “educational affordances” as the “characteristics of an artifact that determine if and how a particular learning behavior could be enacted within a given context” (Kirschner 2002)”. [...] In Dalgarno and Lee 2010, Dalgarno and Lee introduced the term “learning affordances” to describe the tasks and activities a learner may enact in a VLE, tasks that may lead to learning benefits. They claim that learning affordances are the result of VLEs used to facilitate learning tasks that “lead to the development of enhanced spatial knowledge representation”, “would be impractical or impossible to undertake in the real world”, “lead to increased intrinsic motivation and engagement”, “lead to improved transfer of knowledge and skills to real situations”, and “lead to richer and/or more effective collaborative learning” (Mantziou, Papachristos, and Mikropoulos, 2018, p. 1739).

Mantziou, Papachristos, and Mikropoulos (2018) opt to use the term “learning affordances” in their paper, as per Dalgarno and Lee (2010). They suggest “that a new set of learning affordances should be proposed in order to provide a more consistent association among the learning affordances and the “afforded” learning activities”. Their proposed six learning affordances align with the unique characteristics of VR and MUVEs, while being in agreement with Michael's definition of affordances and the principal characteristics of technology (2003). These are a) ‘free navigation’; b) ‘creation’; c) ‘modeling and simulation’; d) ‘multichannel communication’; e) ‘collaboration and cooperation’, and f) ‘content presentation and/or delivery’ (Mantziou, Papachristos, and Mikropoulos, 2018, pp. 1740-1741). Table 2.3 details each of the aforementioned six learning affordances as described in Mantziou, Papachristos, and Mikropoulos (2018, p. 1741).

Table 2.3 Learning affordances of VR and MUVEs (*Source:* Mantziou, Papachristos, and Mikropoulos, 2018, p. 1741)	
1. Free navigation	Originates from the affordances of “3D spatial representations”; “first-person user point of view”, and “first-order experiences” (e.g., “virtual field trips and tours”, and “gameplay”).
2. Creation	Originates from “multisensory intuitive, real time interaction and natural semantics”; “involves building and scripting” (e.g., ‘VLE design’; “virtual building”; ‘behavioral code for virtual objects’, and “course content design”).
3. Modeling and simulation	Originate from affordances such as “size”, “transduction”, “reification”, and “visualization”. Include “data presentation and interpretation”; “modeling” and “reproduction of a real system”; ‘imitation of natural phenomenon’, and ‘virtual experiments’. Relevant activities include “game creation” and “design of environments.”
4. Multichannel communication	Originates from the affordances such as “multisensory intuitive and real time interaction” and “users’ representation by avatars”. Communication involves “discussions, chatting, lectures, and conferences”.
5. Collaboration and cooperation	Originate “from all the affordances” and is amplified by the user experiencing “presence”. Involve “actions like meetings, role-play, and social interaction”.
6. *Content presentation and delivery*	Originate “from all affordances” and “tools like SLOODLE and shared interactive whiteboards”. They involve “actions like presentations and exhibitions”.

2.8.3.1 Overlapping of learning affordances in literature

According to Mantziou, Papachristos, and Mikropoulos (2018), literature presents several 'overlaps' amongst the various learning affordances (e.g., overlaps between "communication and collaboration" and "representations and simulations"). The authors also reflect on literature's 'differences' with regard to the "technological aspects, effectivities and instructional techniques" of the learning affordances. They further point out the "need for clarification and classification of learning activities and their association with learning affordances" (p.1741).

2.9 VR learning activities (task categories classification)

Mantziou, Papachristos, and Mikropoulos (2018) present a comprehensive collection of VR activities (Table 2.4) from various disciplines in "a top-bottom hierarchy of complexity" (p.1743) where the activities become "more complicated and authentic" moving down the categories (p. 1754). Their proposed VR activities (or tasks) align with those presented by Inman et al. (2010) and Dalgarno and Lee (2012). They are also "explicit" and "classified in three hierarchical levels" so that they are aligned with the core values of "learning activities" as well as with MUVEs' instructional design. There are five suggested categories of VR activities (selective coding) which include: a) "content creation"; b) "content exploration and/or interaction with content"; c) "social interaction"; d) "gaming," and e) "representation of real life events and/or situations" (p. 1753-1754).

Table 2.4 Classification scheme of learning activities

(*Source:* Mantziou, Papachristos, and Mikropoulos, 2018, p. 1744)

Selective coding	Axial coding	Open coding
Content creation	Building Scripting Multimedia design Environment design	Build object Build building Script code Create exhibition content Create animation/machinima Design landscape Design environment
Content exploration & interaction with Content	Interaction with content Interaction with simulated environments Exploration of concepts through visualization/modeling	Manipulate object Interact with bot Explore visualization Explore model Watch & present slideshow/presentations Watch videotaped lectures Explore instructional material Explore lab/simulation
	Place exploration	Tour Field trip in plant Field trip in touristic/historical place

Social interaction	Tutorial session delivery & attendance	Attend lecture Deliver lecture Attend conference Participate in tutorial meetings
	Communication	Communicate for task completion Discuss in discussion/meeting SLOODLE Communicate with mentors Communicate in multidisciplinary Context
	Interviewing	Conduct interview
	Collaboration & Cooperation	Collaborate / Cooperate in task completion Collaborate in games Practice collaborative techniques
	Role playing	Play role Play role in a simulated environment Play role as intern

Gaming	Game play	Play with specific game content
	Game creation	Play in game environment Play role inside game Play scavenger hunt Play quiz
Participation in representations of real life *events & situations*	Virtual internship Communication/collaboration with company Virtual participation in social events & actions	Participate in working scenario Work in virtual company Communicate with real vendor/purchaser Collaborate with company Participate in social event Shop Participate in scenario of accident

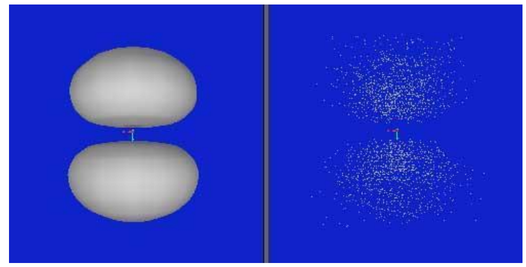
2.10 VR in education

Virtual Reality is often associated with gaming, entertainment, and the military, among others (Voštinár et al., 2021). Nonetheless, a significant body of literature supports the use and potential of VR technology in education. This is based on VR's unique characteristics, which can help students to visualize abstract concepts, observe atomic and planetary events, and interact with their digital environment. All these are possible with the use of virtual reality, which offers users a safe, reproducible, and controllable real-time and real-life experience (Youngblut, 1998). The pertinent virtual activities facilitate students' learning and overall experience by helping them to remember, understand, implement, analyze, evaluate, and create within the educational context (Youngblut, 1998; Mikropoulos and Bellou, in press). Thus, students can construct knowledge in a more hands-on and 'learning-by-doing' educational approach (Youngblut, 1998). Some examples of virtual reality applications in education are depicted in the figure below (Figure 2.7).

Figure 2.7 Examples of educational virtual reality applications

Educational laser laboratory

(Mikropoulos and Strouboulis, 2002)

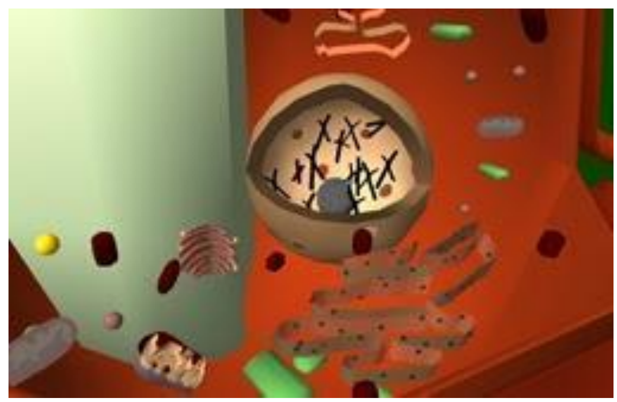


Inside the Quantum Atom

(Kontogeorgiou, Bellou, and Mikropoulos, 2008)

Presence in an ancient Greek house

(Mikropoulos and Strouboulis, 2004)



Internal structure of a plant cell

(Mikropoulos et al., 2003)

2.11 VR and Autism

The role of technology, and more specifically the use of various computer platforms and their benefits for individuals with autism, has been well-documented. A review of the growing body of literature reveals that virtual Reality has been utilized, among other applications, for promoting social skills, communication skills, emotion recognition, and understanding/expression of feelings in autism research. Pertinent research is still in its early stages of data reporting and thus becoming an evidence-based practice. However, relevant findings with successful outcomes have been reported and support VR's positive contribution and overall potential in autism research (Strickland et al., 1996; Murray, 1997; Charitos et al., 2000; Parsons and Mitchell, 2002; Parsons et al., 2006, 2007; Cobb, 2007; Fabri and Moore, 2005; Fabri et al., 2004; Newbutt, 2014).

At this time, the conducted studies have taken place in research labs with small groups of participants and included virtual worlds, (collaborative) environments, and technology centers. Further research is required to investigate the benefits and limitations of VR, which will improve the development of beneficial and appropriate virtual applications for and used by individuals with autism. Below are well-known and indicative research studies in this field that highlight an array of targeted skills (e.g., social skills, emotional skills, vocational skills, functional skills, independent living skills) for individuals with autism (Newbutt, 2014).

2.11.1 VR for social skills in autism

According to the American Psychological Association (APA), social skills are: "a set of learned abilities that enable an individual to interact competently and appropriately in a given social context. The most commonly identified social skills in Western cultures include assertiveness, coping, communication and friendship-making skills, interpersonal problem solving, and the ability to regulate one's cognitions, feelings, and behavior (https://dictionary.apa.org/social-skills)."

Social skills are often an area of concern for individuals with autism. Parsons et al. (2006) investigated the use of VEs for the improvement of the social skills of children with autism. Two high-functioning male adolescents with autism navigated in a virtual café and a bus stop (Figure 2.8). The two participants, with the help of a facilitator, had the opportunity to engage in controlled interactions with virtual characters that were pre-programmed to respond to user input. This qualitative case study employs a user-centered approach, providing valuable insights into participants' performance and their views of the virtual environments.

Regarding the study's findings, researchers stated that participants appeared to interpret the social scenarios appropriately and found the VEs to be helpful in real-life scenarios. Although the participants seemed to have an overall positive response towards the VEs, the researchers reported some "signs of repetitive behaviours, literal interpretation of the scenes, and that the VEs were treated as not having real-world relevance" (p. 186). Nonetheless, this study provided encouraging results that support the notion that VEs could be purposefully utilized and meaningfully interpreted by some individuals with autism (Parsons et al., 2006; Newbutt, 2014).

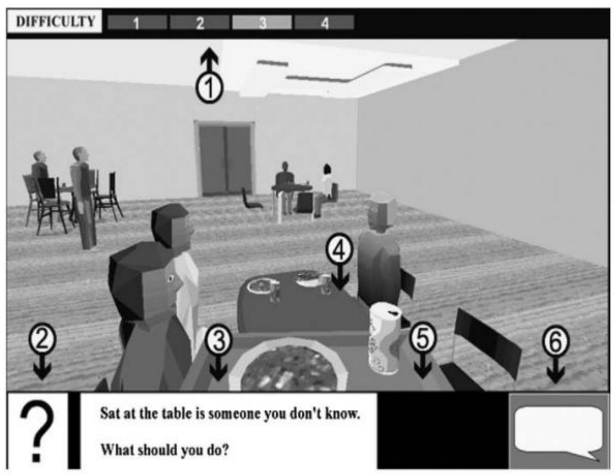


Figure 2.8 Picture depicting key functions of the VE inside the study's virtual café.
(*Source:* Parsons et al. 2006, p.191).

2.11.2 VR for communication skills in autism

According to the American Psychological Association (APA), communication skills are: "the skills required to achieve effective communication. In addition to general language proficiency (adequate vocabulary and knowledge of syntax), effective communication involves the ability to listen and read with comprehension, to present one's thoughts clearly both in speech and in writing, to accept that the perspectives of others may differ from one's own, and to anticipate the effect of what one says or writes on listeners or readers (https://dictionary.apa.org/communication-skills)".

Communication skills are often an area of concern for individuals with autism. Fabri and Moore (2005) targeted their study on the communication skills of individuals with autism, along with other skills (i.e., behavioral/emotional, and daily living/functional skills). The two researchers investigated the use of collaborative virtual environments (CVEs) for enhancing interpersonal communication and emotional recognition skills. They outlined two ongoing empirical studies that employed emotionally expressive avatars. Regarding the second empirical study, the researchers considered it to be "an application of the first study" (p. 92). It aimed to investigate the potential value and benefits of using CVE technology for people with autism in three directions: as a means of assistive technology, educational technology, and addressing Theory of Mind (ToM) deficits. To facilitate and simplify their investigation, the researchers designed a non-collaborative computer system, which, however, utilized an essential component of CVEs: avatars. They used the face/head of a male avatar, which displayed four emotions, i.e., happy, sad, angry, and frightened. One hundred research packs were sent out, and 34 children with autism replied. Each research pack included a CD of the software/interface, a blank diskette, a participant questionnaire, a parent questionnaire, brief instructions, and a stamped, addressed envelope. The participants were asked in a three-staged process a) to recognize portrayed emotions in isolation (Stage 1), b) to predict emotions within a social scenario context (Stage 2), and c) to choose from a number of preselected events the one that resulted in the emotion displayed (Stage 3) (Figure 2.9). According to the study's findings, the authors supported the notion that the participants (all but four, who reported having "severe" autism) were able to recognize and apply the displayed emotions in context. This suggests that virtual tools can be used effectively by some individuals with autism to identify and interpret emotions. Limitations and areas of concern for this study included the limited (or even lack of) information regarding the participants' demographics, the study's settings/environment, participant supervision, and skill generalization. Nonetheless, the study offered evidence that virtual representations of emotions can be recognized by individuals with autism (Fabri and Moore, 2005; Newbutt, 2014).

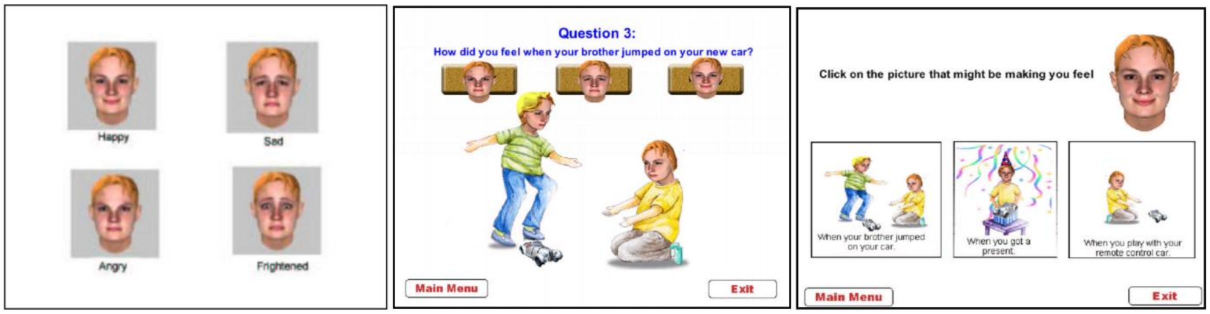


Figure 2.9 Stage 1: representations of emotions in isolation - Stage 2: prediction of emotions within a social scenario context - Stage 3: cause-and-effect event selection for representation of emotions (*Source:* Fabri and Moore, 2005, p. 91-92).

2.11.3 VR for cognitive skills in autism

According to the American Psychological Association (APA), cognitive ability/skills are: **“**the skills involved in performing the tasks associated with perception, learning, memory, understanding, awareness, reasoning, judgment, intuition, and language». Respectively, APA defines cognitive functioning as “the performance of the mental processes of perception, learning, memory, understanding, awareness, reasoning, judgment, intuition, and language” (https://dictionary.apa.org/cognitive-functioning).

Cognitive skills are often an area of concern for individuals with autism. Wang and Reid (2013) investigated the use of a virtual reality cognitive rehabilitation approach to enhance contextual processing in children with autism. In their pilot study with four children with autism, they looked into primary deficits in contextual processing. More specifically, they addressed abstraction and cognitive flexibility with their cognitive rehabilitation approach. Thus, in their study, the children received an intervention to help them “see objects in context by reinforcing attention to pivotal contextual information” (p. 1). According to the study's results, there was a statistically significant improvement in contextual processing and cognitive flexibility. Results were mixed regarding the control test and context-related behaviors. The researchers conclude that their preliminary results are promising; nonetheless, larger-scale studies would provide more evidence on the effectiveness and usability of such an intervention.

2.11.4 VR for daily living functional skills in autism

In Dade's Encyclopedia of Autism Spectrum Disorders, Stabel (2013) defines daily living skills as follows: "The term "daily living skills'' refers to a wide range of personal self-care activities across home, school, work, and community settings. Most daily living skills, such as food preparation and personal hygiene, need to be performed regularly to maintain a reasonable level of health and safety. Adaptive functioning, or an individual's ability to care for themselves and function independently, is a primary consideration when supporting individuals with autism and other disabilities. Daily living skill activities include: personal hygiene and grooming; dressing and undressing; meal preparation and feeding; mobility and transfer; toileting; housekeeping; laundry; home safety; health and medication management, and leisure time and recreation." (Stabel, 2013, p.33/p.839; https://doi.org/10.1007/978-1-4419-1698-3_1417).

Also, in Dade's Encyclopedia of Autism Spectrum Disorders, Hendricks (2013) defines functional life skills as follows: "Functional life skills are the variety of skills which are frequently demanded in natural domestic, vocational, and community environments. The skills involve those immediately applicable to daily life or may also include those that teach students to participate in future environments (Brown et al., 1979). Key qualities of functional skills include the following: it is performed within the context of a real activity; the activity is meaningful to the student; people without disabilities believe the activity serves a purpose; if the student is unable to perform the skill himself or herself, it would need to be completed by another person, and the skill will be needed throughout the person's life." (Hendricks, 2013, p.53/p.1371; https://doi.org/10.1007/978-1-4419-1698-3_157).

Daily living/functional skills are also another area of concern for individuals with autism. Regarding daily living/functional skills, Strickland et al. (1996) published the first article on autism and virtual Reality. It was an early study that aimed to investigate if the two participating children with autism could learn to cross streets safely, accept the VR equipment (head-mounted VR helmets, HMDs), and respond to digital worlds (3D real-life immersive environments) (Figure 2.10). According to the study's findings, participants were able to interact, immerse, explore, and learn from the administered virtual environments while accepting the VR equipment. The study's results, although encouraging, were not generalizable due to the minimal number of participants (Strickland et al., 1996; Newbutt, 2014).

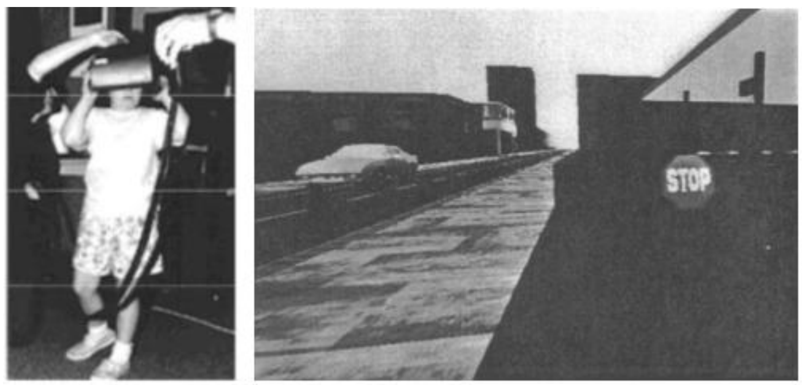


Figure 2.10 Participant wearing an HMD and watching a street scene from the administered virtual world (*Source:* Strickland et al., 2016, p. 655-656).

2.11.5 VR for sensorimotor skills in autism

Machado et al. (2010) define sensorimotor integration "as the capability of the central nervous system to integrate different sources of stimuli, and parallelly, to transform such inputs in motor actions. [...] In other words, it is the dynamic combination of sensory information into an intentional motor response." (p. 427). In a similar vein, (fine/gross) motor actions/behaviors (such as reaching/grasping an object, regulating walking gait, writing, etc.) require the integration of sensory information (Jasmin et al., 2009).

Sensorimotor skills are another area impacted by autism. Valori et al. (2020) studied the interactions between individuals with autism (both children and adults) and Reality/Immersive

Virtual Reality (IVR). Building on the basis that individuals with autism demonstrate a decrease in their use of vision and an increase in their “reliance on body-based information”, seven participants carried out a self-turn activity that took place in a real-life and an IVR environment. There were three sensory conditions in each environment, i.e., a) proprioception; b) vision, and c) vision with proprioception. The targeted task took place in a specially designed room that simulated HMD conditions (Figure 2.11). The results of this study demonstrated that participants who did better under the proprioception-only conditions and worse during the vision-only conditions benefited from the use of IVR. On the other hand, participants who performed differently from the aforementioned benefited from real-life conditions. Thus, authors conclude and suggest that IVR could help (or not) individuals depending on their profiles (p. 1).

Figure 2.11 The study’s IVR room (*Source:* Valori et al., 2020, p. 5)

2.11.6 VR for behavioral and emotional skills in autism

Elchert et al. (2017) state that “Behavioral skills are interpersonal, self-regulatory, and task-related behaviors that connect to successful performance in education and workplace settings. The behavioral skills are designed to help individuals succeed through effective interactions, stress management, and persistent effort. (p.1).” Also, the European Union’s program for lifelong education (Step 4/SFC) notes that “Behavioural skills refer to the reflective ability of the individual in relation to the characteristics of the situations he or she may come up against. This ability may be organizational when the individual reacts in relation to the quality of his or her work, e.g. prioritizing, anticipating, checking, etc.), social or interpersonal, when the person reacts to others and establishes relationships, e.g. negotiating, discussing, cooperating, etc.), or emotional and psychological (when the individual reacts to him or herself and his or her own limits, e.g.: adapting, taking training, etc.)" (https://step4-sfc.eu/OPC-SFC-what-is-it).

Difficulties with behavioral and emotional skills are often reported for individuals with autism. Besides Fabri and Moore's (2005) study, previously described, another well-known study that targets behavior and is amongst the first studies on VR and autism is by Charitos et al. (2000). This study was part of the "Computer-Assisted Education and Communication of Individuals with Autistic Syndrome" project funded by the General Secretariat of Research and Technology of Greece and coordinated by the Department of Informatics, University of Athens. The project's double objective included a) the design of virtual educational environments for individuals with autism, and b) the development of an informative website for parents, professionals, and individuals with autism. The involvement of VR was through a pilot study that aimed to provide educators of children with autism with an educationally supportive technological tool. The core concept of the virtual application was to support the behavioral and organizational skills of 20 students with autism in relation to their everyday functional activities, such as eating, dressing, and sleeping (Figure 2.12). Thus, the 'Returning home' scenario was developed and simulated daily tasks that the children would likely be expected to engage in when 'returning home.' The portrayed functional sequences took place in a virtual, two-story archetypal house under the teachers' supervision and, as needed, with assistance. Charitos et al.'s findings were similar to the ones reported by Strickland et al. (1996). Charitos et al.'s findings were similar to the ones reported by Strickland et al. (1996). The researchers supported that the structured, controllable, and distraction-free virtual environments could support users' functional skills and educational needs. Nonetheless, the small number of participants and the limited reported information regarding their clinical profile and their performance restrict a better understanding of the study's findings, conclusions, and impact (Charitos et al., 2000; Newbutt, 2014).

Figure 2.12 Virtual character demonstrating ‘washing hands’.
(*Source*: Charitos et al., 2000, p. 151)

2.12 Summary

- Literature supports that digital technology can provide predictability, stability, and structure to individuals with autism.
- Research in this area appears to yield positive outcomes and highlight the potential of using technology and computers in autism spectrum disorders.
- Studies that use virtual reality for individuals with autism appear to support and benefit (at least to some degree) their individualized needs.

Chapter 3

THE DELPHI TECHNIQUE

3.1 Introduction

There are several classifications for the numerous existing types of research designs (Keeney, Hasson and McKenna, 2011). Within this diverse range of classifications, Parahoo (2006) identifies a triad of distinct research design types, including the experimental research design, the case study, and the survey design. The latter is often used in healthcare (Keeney, Hasson and McKenna, 2011), social (McKenna, Hasson and Keeney, 2006), and educational research. Surveys aim to collect information (McKenna, Hasson and Keeney, 2006) from specific populations (individuals and groups) to address a particular issue (Keeney, Hasson and McKenna, 2011). This is achieved through the use of questionnaires, interviews, observations, and the analysis of secondary data (McKenna, Hasson and Keeney, 2006). One type of survey that is gaining increasing popularity is the Delphi technique. It is one of the three consensus-reaching methodologies, along with the nominal group technique and the consensus conference method (Keeney, Hasson, and McKenna, 2011).

3.2 History of the Delphi technique

Historically, humankind has been on a continuous quest to foresee the future. Since 1400 BC, oracles had a firm place in the lives of Greeks and Romans. 'Delphi', an archaeological site in Greece on the south-western face of Mount Parnassus, was one of the most important oracle locations in the classical Greek world. People from far and wide consulted the Delphic oracle on a range of topics, including important matters of public policy, personal affairs, and the outcome of wars and the founding of colonies (Keeney, Hasson and McKenna, 2011).

In the vein of predicting military-related outcomes, the Delphi technique itself was developed at the beginning of the Cold War to forecast the impact of technology on warfare (Custer et al., 1999). Entitled Project RAND (1959), the Delphi method was developed by Olaf Helmer, a German-American logician and futurologist; Norman Dalkey, an American mathematician; and Nicholas Rescher, a German-American philosopher. The initial application of the method required experts to provide their opinions on the probability, frequency, and intensity of potential enemy attacks, as well as the number of atomic bombs required to destroy a specific target.

3.3 Definition of the Delphi technique

With a plethora of definitions and broader definitions of the Delphi technique, scholars find common ground in that the Delphi technique aims for a group of experts to reach an agreement (consensus) about a significant matter while following a multi-step process (Keeney, Hasson, McKenna, 2011; McKenna, 1994a). Two of the technique's original developers, Dalkey and Helmer (1963), defined Delphi as 'a method used to obtain the most reliable consensus of a group of experts by a series of intensive questionnaires interspersed with controlled feedback' (p. 458). In the same vein, Lynn et al. (1998) and Reid (1998) defined the technique as the systematic collection and distilled synthesis of an expert panel's opinion into informed consensus. The issue in question would be specific and important, with an agreement that had not previously been achieved (McKenna, 1994a). For example, McIlfatrick and Keeney (2003) used the classical Delphi format to set priorities in cancer research, utilizing 112 nurses attending a cancer nursing research conference in Northern Ireland as their expert panelists.

As the technique's usage increased, so did its different adaptations and definitions. These definitions attempted to reflect the technique's constant adaptations, which inevitably lead to numerous interpretations. Although today there are several different definitions of the Delphi, they usually tend to remain true to the technique's essence, as encapsulated in Dalkey and Helmer's definition. However, significant concerns are raised as there are various existing forms of the Delphi (e.g., 'modified Delphi', 'decision Delphi' own responses, 'policy Delphi', 'real-time Delphi', 'argument Delphi') and often, researchers use different approaches to the technique's implementation. This has led to several questions and criticism in terms of the credibility, validity, and reliability of the method and its findings (Sackman, 1975), as the use of various adaptations (Mead, 1991; Butterworth and Bishop, 1995; Green et al., 1999) can be done without adequate consideration of the consequences.

3.4 The Delphi process: the original Delphi (Classical Delphi)

The original form of the technique is today known and referred to as the 'Classical Delphi'. The process is as follows (Keeney, Hasson, and McKenna, 2011). Initially, the researchers assemble a group of experts (also known as a panel of experts, panelists, or experts) who are asked to reach an agreement regarding a significant matter that has not been previously achieved. Through an iterative process of at least two rounds, the researchers initiate the process by mailing the first questionnaire to the experts. Typically, the first round's questionnaire includes open-ended questions, which promote idea generation and allow experts to freely share their views and opinions about the matter under study. Once the experts have completed answering the questionnaire, their responses are collected and analyzed by the researchers to develop the second round's questionnaire and provide feedback to the experts (i.e., in the form of a summary of their responses or those of other experts). The latter will encourage each expert to possibly reconsider_their answers and approach in light of the other experts' answers. The second questionnaire usually has the form of (closed-ended) questions or statements that the experts are asked to rate or rank and then return to the researchers. The researchers will again collect and analyze the experts' answers, based on which the third round's questionnaire is produced, and so on. The rounds subsequent to the first round, i.e., round two, round three, round four, etc., will be similar in terms of the steps and the process that is being followed in round two and will be repeated until the experts reach the (desired/pre-selected) level of consensus that the researchers have set for the items (all or some) under investigation.

According to Hitch and Murgatroyd (1983), the Delphi technique a highly controlled meeting of experts, facilitated by a chairperson who is adept at summing up the feelings of the meeting by reflecting the participants' own views back to them in such a way that they can proceed further – the only difference is that the individual responses of the members are unknown to one another. Overall, it is a (systematic) multi-stage process as one stage leads to the development of the next one, by distilling the experts' answers and while providing (controlled) feedback throughout this process and until agreement (consensus) has been reached (Sumsion, 1998).

3.5 Priority setting versus consensus

The Delphi technique is primarily utilized in health, education, and technology research for two primary purposes: priority setting and consensus building. In both cases, invited participants can be professionals, academics, and/or researchers of the pertinent fields, who form the panel of experts. Regarding priority setting, for example, this can include identifying research priorities for teachers in special education, as well as for individuals with autism and specific learning difficulties. There is a large number of studies that research these areas and can help prioritize the areas of research that should be funded in the short, medium, and long term. On the other hand, a Delphi study can aim to gain consensus about specific issues and views amongst the participating experts. In that case, experts are asked to rate or rank items that could either originate from the experts' answers in Delphi's first round (e.g., as in 'Classical Delphi') or from the body of literature (or focus groups or interviews/other sources can be) (e.g., as in 'modified Delphi'). The researchers set a level of consensus (e.g., 80%), which is the percentage of experts that need to be in agreement about the importance or position of the statements under investigation. Once that level is achieved, it is when consensus has been reached, and thus the study can be considered completed. Consensus studies have been widely used in health and education research.

3.5.1 Non-consensus Delphi

Typically, many studies that use the Delphi technique aim to reach consensus. However, as more modifications and new adaptations of this method appear, there are cases where consensus is not the objective (Keeney, Hasson, and McKenna, 2011). For example, 'Policy Delphi' seeks to identify potential solutions to policy issues by highlighting opposing views. It is through the experts' opposing arguments of the expert panel that researchers who employ a 'Policy Delphi' attempt to identify the pros and cons of an existing policy that will ultimately help them to uncover and resolve pertinent policy issues in the most informed manner (Keeney, Hasson, McKenna, 2011; Turoff and Linstone, 2002; Shelton and Creghan, 2015; Turoff, 1970). Thus, reaching a consensus is not the primary goal of this type of Delphi; consensus is actually not a desired outcome, and in some cases, researchers can even design the study in a manner that discourages consensus from being reached (Turoff and Linstone, 2002; Turoff, 1970). Other examples of non-consensus Delphi variations include the 'Argument Delphi', a derivative of the 'Policy Delphi' (Kuusi, 1999), and the 'Disaggregation Policy Delphi', which uses cluster analysis to group probable and preferable future scenarios (Tapio, 2002).

3.6 Types of Delphi

Indicative of Delphi's adaptive flexibility and, at the same time, its controversial variability is Mullen's (2003) identification of 20 different ways researchers use to refer to the Delphi method. These ways included: 1. Delphi; 2. the Delphi; 3. (the) Delphi method; 4. Delphi research; 5. (the) Delphi process; 6. (the) Delphi methodology; 7. the Delphi approach; 8. (the) Delphi technique; 9. Delphi survey; 10. Delphi concept; 11. Delphi applications; 12. the Delphi expert; 13. consultation method; 14. a Delphi inquiry; 15. Delphi panels; 16. the Delphi panel technique; 17. the Delphi panel method; 18. the Delphi survey technique; 19. a Delphi consultation; 20. Delphi investigation (p.39). Such variances can enhance confusion about the technique.

In the same vein, as previously mentioned, the Delphi technique was soon employed in other studies and research fields after its inception. Due to its flexibility and lack of universally accepted guidelines, several adaptations and modifications of the technique have emerged and been used in numerous studies. Keeney, Hasson, and McKenna (2011) provide a synoptic table of the technique's different variations and their characteristics (Table 3.1).

Table 3.1 Delphi variations

(*Source:* Keeney, Hasson and McKenna ,2011, p. 7)

Classical Delphi	Uses an open first round to facilitate idea generation to elicit opinion and gain consensus. Uses three or more postal rounds. Can be administered by email.
Modified Delphi	Modification usually takes the form of replacing the first postal round with face-to-face interviews or focus group. May use fewer than three postal or email rounds.
Decision Delphi	Same process usually adopted as a classical Delphi. Focuses on making decisions rather than coming to consensus.
Policy Delphi	Uses the opinions of experts to come to consensus and agree future policy on a given topic.
Real Time Delphi	Similar process to classical Delphi except that experts may be in the same room. Consensus reached in real time rather than by post. Sometimes referred to as a consensus conference.
e-Delphi	Similar process to the classical Delphi but administered by email or online web survey.
Technological Delphi	Similar to the real time Delphi but using technology, such as handheld keypads allowing experts to respond to questions immediately while the technology works out the mean/median and allows instant feedback allowing experts the chance to re-vote moving towards consensus in the light of group opinion.
Online Delphi	Same process at classical Delphi but questionnaires are completed and submitted online.
Argument Delphi	Focused on the production of relevant factual arguments. Derivative of the Policy Delphi Non-consensus Delphi.
Disaggregative Delphi	Goal of consensus not adopted. Conducts various scenarios of the future for discussion. Uses cluster analysis.

3.7 Sampling and the use of experts

3.7.1 Defining 'expert' and employing an expert panel

Participant selection is a crucial part of any study. In the case of the Delphi study, it is the first step of this multi-stage process and one that has also faced intense criticism. In Delphi, the participating individuals, often referred to as 'experts', are purposefully and intentionally selected by the researchers. They are considered to be 'informed individuals' (McKenna, 1994a) and 'specialists' (Goodman, 1987) in their field with knowledge about the subject under investigation (Davidson et al., 1997; Lemmer, 1998; Green et al., 1999

However, Delphi's critics and the research community overall raise several questions and methodological concerns about the identification and selection process of Delphi's experts (Sackman, 1975; Linstone and Turoff, 1975; McKenna, 1994a). Linstone (Linstone, 1975; Linstone and Turoff, 1975) comments on the 'illusory expertise' (p.566) of the Delphi participants, and Goodman (1987) reflects on the 'potentially misleading title of expert' (p. 732). On the same vein, Keeney, Hasson, and McKenna (2011) state: "The claim of the 'Delphi' to represent valid expert opinion has been criticized as scientifically untenable and overstated (Strauss and Zeigler, 1975a)." (p.18).

Achieving or even seeking a balance between the different and contrasting approaches of the Delphi method is a rather challenging task. Employing an expert panel is no exception to that. The question of whether individuals knowledgeable in a particular area can be considered experts is also a controversial matter. It is suggested that individuals who willingly participate in discussions are more likely to be involved, remain engaged, and incorporate the study's findings in their field. Participants' interest in the subject under study is directly correlated with the level of their engagement. Nonetheless, participants must be to some degree objective so that the information shared is current and up to date (Goodman, 1987). This balance is difficult to achieve and justify to the consumers of the finished research.

3.7.2 Size of the expert panel

Traditionally, Delphi studies employ a heterogeneous panel of experts. The rationale behind this argument lies in the fact that heterogeneity, in the form of recruiting different groups of experts, can ensure that various points of view and opinions about the subject under study are represented (Moore, 1987). In this vein, it is becoming increasingly frequent for researchers to establish eligibility criteria for the inclusion (or exclusion) of experts with specific profiles and qualifications (Keeney et al., 2001, 2006). Some examples of eligibility criteria that researchers set include the number of publications in which participating individuals have been involved in that specific area, their years of experience in that field, their interest in the study's topic, and their time availability, among others.

Overall, a study's number of participants and their heterogeneity depend on the study's purpose, research design, and data collection timeframe (Goodman, 1987; McKenna, 1994a; Green et al., 1999). In the case of the Delphi study, and nonetheless, the size of the panel and its characteristics, such as its heterogeneity or homogeneity, its relation to other experts, and its selection process, are also some of the points of debate and criticism amongst the researchers (Williams and Webb, 1994a, 1994b).

3.7.3 Valid opinion

Another distinct characteristic of the Delphi method is that it 'elicits valid opinion from experts in the area' (Keeney, Hasson and McKenna, 2011: p. 9). This statement comes with a series of acknowledgments, starting with the fact that an 'opinion' is a belief, a view, or a judgement about someone or something. Thus, an opinion is not necessarily backed by evidence and facts, nor supported by knowledge. It can be subjective, disputable, and inconclusive (www.merriam-webster.com, oxfordlearnersdictionaries.com, lexico.com). The notion that a Delphi study aims to extract valid expert opinions, rather than produce "right or wrong answers", is associated with two key elements of this methodology: experts' feedback and anonymity (Rowe et al., 2005). They will both be further described later in this chapter.

3.8 Anonymity

Typically, participants in a Delphi research are warranted anonymity throughout the study. This assurance encourages experts to share their views freely and truthfully about the subject under study. Anonymity ensures that participants are not compelled to adopt the opinions of renowned experts (Couper, 1984) and consider all experts' views equally. Each expert opinion is provided independently, presented impartially, and weighted equally amongst the participants and the researcher(s) (Goodman, 1987). With their identities concealed, 'subject bias is eliminated' (Goodman, 1987; Jeffery et al., 1995) and the researcher(s) can obtain valuable and original data. Nonetheless, and besides the advantages that come with ensuring participants' anonymity, some concerns have been raised. For example, researchers are unable to determine with certainty whether participants' change of opinion is attributed to the new information, or, beyond the shield of anonymity, experts tend to follow the panel's standpoint. Furthermore, Goodman (1987) suggests that anonymity can lead to irresponsibility and misjudgment of views and opinions, which can have detrimental effects on the study's outcomes.

3.8.1 Quasi-anonymity

Researchers agree that achieving complete anonymity when conducting a Delphi study is difficult, if not impossible. This is attributed to two main reasons. One is that the researcher(s) are aware of the experts' identity and their answers. Also, there is a good chance that the participants already know each other, although they cannot assign responses to specific individuals. The reason for the latter is that researchers derive their panelists from a specific and limited pool of qualifying participants. The knowledge of being part of a selective group can motivate participants who are likely familiar with the work of their peers, if not their peers themselves. Nonetheless, they cannot interact with them throughout the Delphi study. In light of the aforementioned, McKenna (1994a) used the term ‘quasi-anonymity’ to refer to the contradiction of the participants possibly knowing each other while their opinions and views are anonymous.

3.8.2 Group dynamics

Individuals belonging to a group, i.e., two or more people who have ‘some unifying relationship’ (https://www.merriam-webster.com/dictionary/group), develop behaviors and processes that their interactions affect, shape, and form. Group dynamics refers to these behaviors and processes that are not typically observed amongst individuals who do not share a connection of some type. Delphi panels are a characteristic example of a group of individuals brought together by their common attributes (i.e., knowledge, experience, and overall expertise on a specific matter), which develop dynamic relationships and processes. Group dynamics, along with controlled feedback, have the potential to steer participants' opinions in one direction or another, resulting in their alignment and ultimately in reaching consensus on the subject under study.

3.9 Delphi rounds

Delphi studies employ a number of rounds that send out questionnaires and controlled feedback (i.e., summary of the previous round’s findings) to the participating experts, and continue until consensus is reached (Beretta, 1996; Green *et al.*, 1999). The number of rounds required for the expert panel to reach consensus is unclear and difficult to (pre)determine. It depends on various variables, such as the estimated time required to complete the study, the time and availability of the experts, and the number and type of questions (i.e., open-ended or closed-ended) used in the initial round. Today, the rounds of a Delphi study can be as few as 2-3, whereas the original Delphi employed a total of four rounds (Young &Hogben, 1978). Overall, researchers employ as many rounds as needed to accommodate the aim(s) and needs of their specific study (Proctor and Hunt, 1994; Beech, 1997; Green *et al.*, 1999). Another factor that researchers consider is that maintaining a high response rate throughout the study is desirable yet challenging to achieve, especially when multiple rounds are employed. Thus, the participating experts need to be highly interested in the study's subject and/or receive some type of reward or incentive for their (continuing) participation.

3.9.1 Round 1

Typically, the classical Delphi uses open-ended questions in its first round. This allows experts to generate ideas and to provide their responses freely and openly. It is an approach that can lead to an abundance of raw/primary data, which makes their management further challenging. This is particularly evident when researchers choose to include these large volumes of qualitative data from Round 1, without previously collapsing them (Proctor and Hunt, 1994). It is a methodology decision that, although inclusive, results in long and extensive questionnaires in Round 2. Studies show that lengthy questionnaires can discourage individuals from participating and are overall hard to sustain (Green et al., 1999). Furthermore, if the initial questions were not appropriately and adequately phrased, then the validity and reliability of the obtained data, as well as the study itself, are unavoidably compromised.

Given the aforementioned, there is a growing trend towards providing pre-existing information for ranking or response in Round 1, rather than using open-ended questions. This approach could increase Delphi's efficiency, as it is known to potentially be a very time-consuming methodology (Duffield, 1993; Jenkins and Smith, 1994). Nonetheless, and although promising, this suggestion has raised some concerns. Critics of this suggestion argue that there may be a potential bias in the experts' responses and/or a reduction in the available/provided options.

3.9.2 Subsequent rounds

In the subsequent rounds of a Delphi study, participating experts receive two items: the pertinent round's questionnaire, accompanied by a summary of the previous round's findings. Regarding the questionnaire, it is considered a structured questionnaire that incorporates the processed findings from the previous round. Similarly, the sent-out summary reflects the previous round's findings and is considered to be more of a product of controlled feedback (Buck et al., 1993). This process is reiterated throughout the remaining rounds of the Delphi study and is considered to encourage and motivate experts' participation (Walker and Selfe, 1996). The benefits of this approach are progressive and include the systematic and swift collection of the panel's responses (Buck et al., 1993), the active involvement of the experts in the questionnaire development, and fostering participants' perception and feelings of ownership and acceptance for the study's results (McKenna, 1994a). These are important elements for the success of any development program (Shepard, 1995) and particularly in the case of the Delphi study, for which they also serve as motives and benefits for this method.

Critics of the method have raised certain concerns regarding data management and participant attrition in these subsequent rounds. There are little to no (universal) guidelines regarding the management and balance of the generated qualitative and quantitative data of a Delphi study (Green et al., 1999). This inevitably leads to different implementation, interpretation, and reporting approaches, which can ultimately harm the method's integrity. Regarding the potential attrition of participants, it is important that panelists remain involved and participate in all rounds (Buck et al., 1993). Their consistent participation is crucial for reaching a consensus. Nonetheless, participant attrition has been observed throughout the rounds of Delphi studies, especially in the final round. Researchers attempt to address this matter by administering two or three rounds, instead of the original recommendation of four rounds. Another proposed approach to addressing this issue is the use of in-person interviews in the initial round of the Delphi study. McKenna (1994a) supports that this approach increases the return rate of postal questionnaires in the study's second round.

3.10 Response rates

It is well known that the use of questionnaires in research, overall, comes along with a high risk of a decreased response rate. This is even more evident in the case of the Delphi study, as it requires participants to complete several questionnaires, thereby significantly increasing the likelihood of low response rates. One way researchers use to address, if not resolve, this issue is the use of reminders (such as letters, emails, phone calls) to non-responders.

3.10.1 Enhancing response rate

Researchers resort to various measures to enhance the participants' engagement and response rate throughout the Delphi study. Some of these measures include ensuring participants' interest and partnership, encouraging their involvement, providing reminders that the development of the questionnaires relies on their input, and keeping them updated on the study progress. Nonetheless, concerns regarding this approach suggest that panelists could possibly feel obligated to participate in the Delphi study, whereas they would prefer to opt out (Beretta, 1996). Another suggestion for enhancing experts' participation and response rate is to encourage a more personal connection with them and have an overall more personalized approach (McKenna, 1994b). This can begin as early as the preliminary steps of the Delphi study, before the first round. It is the point at which the researcher initiates the initial communication with the experts regarding the scope and purpose of the study, as well as the acquisition of informed consent. It explains the role and responsibilities of the experts in the Delphi study. In the same vein, another relatively recent suggestion is to recruit and commit experts to participate before the Delphi study even begins (Hung et al., 2008). Although there is no sufficient evidence to support this suggestion, researchers describe it as sending out recruiting letters to the experts that provide them with information about the study (aim and purpose), the projected number of rounds, and participants' consent. Moreover, for the first round of a Delphi study, the use of in-person interviews has also been proposed. McKenna (1994b) achieved an impressive and rare 100% response rate in the first round of a Delphi study, utilizing in-person interviews.

Additionally, between the study's rounds, researchers emphasize the importance of following up, particularly with non-responding participants. This could involve sending additional copies of the questionnaires and emailing or calling non-respondents (McIlfatrick & Keeney, 2003; McKenna and Keeney, 2004). Another way to sustain experts' engagement is to provide them with feedback in a timely and interesting manner. This is believed to foster their interest and thus their participation. Overall, suggestions like the aforementioned rely on the notion that a personalized relationship between the researcher and the experts can increase the latter's commitment, participation, and, consequently, their response rate.

3.11 Consensus

There are several truths and misconceptions regarding the Delphi method and reaching consensus. Researchers advise caution when interpreting the results of the Delphi method, pointing out that there are no right or wrong answers when it comes to the experts' opinions. Thus, achieving consensus is merely that, i.e., a group of specialists reaching an agreement on some or all items under study. In contrast to other methodologies (e.g., focus groups), participants in a Delphi study are unable to directly discuss and elaborate on their opinions in person (Goodman, 1987; Walker and Selfe, 1996). This led some researchers to suggest that the Delphi method forces consensus amongst experts, whereas others support that it alleviates any pressure for conformity from more opinionated participants. Nonetheless, researchers agree that the Delphi is no substitute for original, empirical, and peer-reviewed research and that its results should be critically evaluated. Once these aspects are taken into consideration, then consensus can be reached, and the Delphi can be viewed as a valuable research tool.

3.11.1 Consensus in expert panels

Exploring consensus agreement within expert panels is a practice that is gradually increasing and is employed in various research areas. Studies show that when extreme views are removed, consensus is obtainable. This is reasonable as the main scope of a Delphi is for the participating experts to establish agreement on the issues under debate.

3.11.2 Concept of consensus

Consensus can have different interpretations depending on the context in which it is being used. Overall, it is considered synonymous with ‘collective agreement’ when a broad spectrum of diverse views is debated. Graham et al. (2003) defined consensus in Delphi as ‘a condition of homogeneity or consistency of opinion among the panelists’ (pp.1152–1153). Thus, participating stakeholders adopt an opinion or view through collaboration, rather than as a result of plurality and/or compromise. This process is regulated by a facilitator, who, in the case of the Delphi study, is the researcher; the process involves iterative rounds of questionnaires.

3.12 Comparison of Delphi with other consensus methods

There are three consensus-building techniques: the nominal group technique (NGT) (Carney et al., 1996), the consensus conference (Jones & Hunter, 1995), and the Delphi technique. All three methods rely on a collaborative decision-making and problem-solving approach. This approach aims for participants to reach consensus on complex and conflicting issues through idea generation and stakeholder collaboration (Burgess and Spangler, 2003). These methods are further described in the following sections of this chapter.

3.12.1 Nominal group technique

The Nominal Group Technique (NGT) is a rapid and efficient method (Carney et al., 1996) that is used for data collection, program planning, evaluation, adult education, curriculum design, and exploratory research. Under the direction of a facilitator/moderator, participants brainstorm and rank solutions to a particular issue through a collective and structured process of problem identification, idea generation, and prioritization (Moore, 1987; Scott and Deadrick, 1982).

Initially, the facilitator presents the issue under investigation and the pertinent question(s) to the participants. Then, the panelists are asked to silently and individually brainstorm solutions, which they will subsequently explain equally to the other participants (Gibson, 2001). Proposed solutions are rated/ranked (Jones and Hunter, 1995) with the less favorable being eliminated. This process, often two rounds (Jones and Hunter, 1995), is repeated until a high level of consensus is reached.

3.12.2 Consensus conference

Consensus conferences, as the name of the method suggests, are conferences where specialists are presented with an important issue (e.g., policy decisions, establishment of research priorities) for which a collective agreement needs to be reached. Participants discuss and weigh the pros and cons of the pertinent matter before they reveal their preference/judgment, for example, by voting. Critics of this method state that consensus conferences are costly, sample size and participant selection are challenging, and opinionated participants can steer the direction of the discussion. Nonetheless, supporters of this method point out that the benefits of adopting a consensus conference approach can outweigh the negatives. Thus, in-person discussions and exposure to the same presentations offer participants a better understanding of the topic at hand, which facilitates the achievement of a high level of consensus.

3.13 Limitations of the Delphi

3.13.1 Pressures of conformity

Delphi critics and supporters often share contradicting arguments regarding key elements of the method. As a group decision-making technique, Delphi panels can potentially include authoritative and opinionated individuals. The aforementioned panelists could apply pressure to other participants, leading them to conform to their opinions or even pushing them to opt out of the process (Rowe and Wright, 1999; Stewart, 1987; Woudenberg, 1991; Geist, 2009). This is something that could result in poor and misleading study findings. On the other hand, supporters of the method claim the exact opposite, i.e., that the Delphi method successfully avoids the pitfalls of group conformity and therefore achieves a genuine representation of the panel's views and consensus upon them (Fisher, 1978; Veal, 1992; Moeller and Shafer, 1994).

Some other interesting arguments regarding the lack (or not) of group pressure and conformity in Delphi studies include Bardecki's (1984) observations. He pointed out that participant attrition can create a false sense of consensus. Thus, the panelists who initially participated in the study but later opted out did not participate in its final round, nor did they contribute to reaching consensus on all or some of the study's items. Furthermore, several studies (Cyphert and Gant, 1970; Scheibe et al., 1975) indicate that participants tend to align with the feedback they receive. This is the controlled summary that the researcher sends to the panelists about the results of the previous round. This is observed regardless of whether the feedback is an accurate representation or a complete misrepresentation of the round's results. In that vein, Cyphert and Gant's (1970) study was eye-opening in this matter. The researchers changed the rating of an item from negative to positive, as well as manipulated the justification for the initially negative reasoning to a positive one. What Cyphert and Gant ultimately observed in the final round was that this particular item achieved a well-above-average consensus, as opposed to initially obtaining a very low one. Thus, researchers should use caution when interpreting consensus and refrain from equating it to validity (Stewart, 1987) and truth, as it can only represent a 'collective bias rather than wisdom' (Chan, 1982, p. 440).

3.14 Summary

- The Delphi method utilizes the opinions of an expert group to reach consensus on an issue.
- There are various modifications of the technique, all of which employ a number of rounds to collect and distill experts' opinions.

- Participating experts receive controlled feedback after completing each round to reflect on their individual and group views.
- Reaching consensus signals the experts' agreement on the issue under investigation and should not be viewed as finding "the correct answer."

Chapter 4

LITERATURE REVIEW

4.1 Introduction

As mentioned in Chapter 1, Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder. It has life-long and persistent characteristics that affect the individual's social communication, interactions, and behavioral patterns (stereotypical behaviors, restricted interests, and repetitive activities) (Mesa-Gresa et al., 2018; APA-DSM-5, 2013; NINDS-NIH, 2015). According to the World Health Organization (2021), "Autism spectrum disorders (ASD) are a diverse group of conditions. Detection of autism characteristics can start in early childhood, but the disorder is often not diagnosed until much later. About one in 270 people has an ASD (GBD, 2019)." The Organization further notes that the needs, strengths, and weaknesses of individuals with autism can vary and change. Thus, these individuals can either live independently or, in severe cases, need lifelong assistance. Research shows that (evidence-based) psychosocial, behavioral, and speech/language interventions can help with communication and socialization. Thus, these interventions can positively impact the quality of life of individuals in the spectrum and their families, caregivers, and providers (WHO, 2021).

Regarding Virtual Reality, as mentioned in Chapter 2, pertinent literature offers various definitions, with one of the most recent ones provided by Merriam-Webster (2021). It defines VR as "an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment" (Mesa-Gresa et al., 2018, p.1). Virtual Reality (VR) uses different technologies (software and hardware) to offer users a multisensory experience of merged real and digital worlds found in gaming and virtual environments (Mesa-Gresa et al., 2018). Due to its unique characteristics, VR is considered an innovative and effective treatment, intervention, rehabilitation (Bird et al., 2017; Albiol-Perez, 2017), and diagnostical (Orlosky et al., 2017; Areces et al., 2016) approach in a variety of fields (Mesa-Gresa et al., 2018) of health such as medicine, mental health (Garcia-Palacios et al., 2015; Bekelis et al., 2017), surgery training (Phé et al., 2016; Pulijala et al., 2017) as well as education/teaching (e.g., intervention and training).

With regard to medicine and mental health, a variety of disorders ranging from Post-Traumatic Stress Disorder (PTSD) and Obsessive-Compulsive Disorder (OCD) to Intellectual Disability (ID) and Autism Spectrum Disorder (ASD) use VR as a treatment (Mesa-Gresa et al., 2018). As autism prevalence increases, it is imperative to provide effective intervention and treatment. Due to VR's unique characteristics, there are significant advantages concerning its use for autism interventions. Studies have shown that VR can possess ecological validity (Mesa-Gresa et al., 2018; Jarrold et al., 2013) when used in such interventions. It provides users with realistic training in a controllable virtual environment tailored to their individual needs, strengths, and weaknesses (Mesa-Gresa et al., 2018).

It is noteworthy that numerous studies have reported benefits associated with the use of VR for individuals with autism. Furthermore, they often refer to the potential of VR in autism intervention and the need for more and larger-scale empirical studies. It is indicative that from the first emerging studies back in 1996-1997, there is significant heterogeneity concerning the type of VR technology, the targeted skills, the designed VR tasks, and the number and clinical profile of the participants (small samples with underreported diagnostic and clinical information). Currently, there is no clear and universally accepted framework for designing such virtual environments, nor is one widely or universally adopted. Often, each study follows and suggests its own design guidelines, depending on the study's purpose and aim, as well as the research team's background (knowledge, experience, and education).

4.2 Literature reviews for VR and autism

Researching the pertinent literature reveals reviews that attempt to explore the connection between VR and autism. According to Mesa-Gresa et al. (2018), since 2015, literature reviews such as those by Mishkind et al. (2017), Liu et al. (2017), and Van Bennekom et al. (2017) have contributed to the field to some degree. However, these reviews were either not focused on autism or its intervention. Thus, Mishkind et al. (2017) reviewed VR treatments in psychiatry and disorders such as phobias, anxiety, and PTSD, leaving out autism. Liu et al.'s (2017) comprehensive review focused on the engineering aspect of technological advances for the diagnosis and treatment of autism. Van Bennekom et al. (2017) conducted a literature review on the use of virtual environments for assessing psychiatric disorders, which, like Mishkind et al. (2017), did not focus on autism (studies pertaining to intervention were excluded).

Furthermore, Provoost et al.'s (2017) systematic review looked into the use of embodied conversational agents (ECAs), i.e., digital conversational characters, for 'the delivery of automated human support factors'. However, their review included VR only if ECAs were involved. Lau et al.'s (2017) systematic review analyzed the use of serious games for mental health disorders while noting that not all serious games can be considered VR and vice versa. In Parson's (2016) conceptual review, questions were raised regarding the veridicality of VR for autism. In den Brok and Sterkenburg's (2015) systematic review, studies focusing on the use of self-controlled technologies for supporting skill attainment in individuals with intellectual disability (ID) were the primary focus. In contrast, studies concerning VR and autism were excluded. Irish's (2013) literature review focuses on single-user environments for social skills training in adolescents with autism. Duffield et al. (2018) published a brief report on a systematic review examining virtual environments as an assessment modality for pediatric ASD populations. Mesa-Gresa et al. (2018) conducted an evidence-based systematic review examining the effectiveness of VR in children with autism.

Overall, the pertinent literature reports promising outcomes and potential benefits of using virtual reality for individuals with autism (Parsons, 2016). Nonetheless, the autism population, study participants, and study designs are highly heterogeneous; thus, current empirical evidence appears insufficient, and particular caution is required to prevent overgeneralization of results.

4.3 Literature reviews for design guidelines for VR and autism

Although some empirical studies of VR for individuals with autism refer to applied design guidelines, there are few literature reviews in this area. A study that further looks into this matter is Bozgeyikli et al.'s (2017) systematic literature review (survey) on design considerations for VR for individuals with autism. It focuses on training/targeted intervention with an eye on other potential areas for additional benefits. The advantages of using VR for autism and the design challenges for future training applications were presented. Regarding the latter, the authors present their findings from the literature, which are primarily based on observations from user studies that explore the usefulness of VR as a training tool for individuals with autism. They present and apply a new taxonomy that classifies previous VR works on training individuals with autism according to immersive and regular (non-immersive) VR systems and types of social, life, and safety skills based on a systematic literature review. They also examine the common design considerations from previous VR studies for training individuals with autism. Lastly, based on their systematic literature reviews, they identify research gaps and present future research considerations.

4.3.1 Systematic literature review for design guidelines for VR and autism

The increasing prevalence of autism makes it imperative to provide effective intervention and treatment. Therefore, having a framework for design guidelines that could support the successful and therefore beneficial implementation of such virtual environments is a significant step towards this goal. The active intervention research literature serves as a source for identifying interventions and treatments that generate positive outcomes for individuals with autism and their stakeholders (e.g., family, friends, teachers). As previously mentioned, there are currently very few literature reviews on this matter. To address this gap, we conducted a systematic literature review regarding the design guidelines for virtual environments for individuals with autism. More specifically, the purpose of this systematic literature review was to report as comprehensively as possible the intervention literature that identifies (evidence-based) design guidelines for virtual reality environments and intervention practices for individuals with autism.

4.4 Literature review

Guidelines for conducting a literature review discussed in Khan et al. (2003), Uman (2011), Duffield et al. (2017), Mesa-Gresa et al. (2018), Kitchenham's (2004) Mesa-Gresa et al. (2018) were taken into consideration. We took the following five steps for conducting this literature review:

- Step 1: Framing questions for the review
- Step 2: Identifying relevant work
- Step 3: Assessing the study quality
- Step 4: Summarizing the evidence
- Step 5: Reporting the findings

4.5 Step 1: Framing questions for the review

Initially, the following "free-form" (wh-) questions (Duffield et al., 2018) were formulated for the needs of this literature review:

SR-Q1: What affordances (design guidelines) are used?
SR-Q2: What VR technologies are utilized?
SR-Q3: What skills are targeted?

4.6 Step 2: Identifying relevant work

4.6.1 Definitions of terms for establishing the scope of the review

Initially, to establish and define the scope of this review, the targeted terms and their definitions were identified, starting specifically with the definitions of "autism" and "virtual reality." Autism, being a complex neurobehavioral condition with a range of symptoms, has several definitions. The Diagnostic and Statistical Manual of Mental Disorders (DSM), a principal authority for psychiatric diagnoses, contains descriptions, symptoms, and other criteria for diagnosing mental disorders, including autism. It provides a common language for clinicians and researchers to communicate about their patients and study participants. It was selected to derive autism-related search terms, although it does not provide a solid definition of the disorder. It is noted that pertinent searches included the last two editions of the DSM, i.e., DSM-IV-TR (2000) and DSM-5 (2013). This was because the latest edition, although in most respects was not greatly modified from the DSM-IV-TR, had some significant differences.

More specifically, notable changes in the DSM-5 included, among others: a) renaming the diagnosis to Autism Spectrum Disorder (ASD) from Autistic Disorder, b) elimination of sub-diagnoses (Autistic Disorder, Asperger Syndrome, Pervasive Developmental Disorder Not Otherwise Specified, Disintegrative Disorder) - with the reconceptualization of Asperger syndrome from a distinct disorder to an Autism Spectrum Disorder standing out, and c) the modification of autism criteria (in DSM-IV-TR, symptoms were divided into three areas, i.e., social reciprocity, communicative intent, restricted and repetitive behaviors), whereas, in DSM-5, the new diagnostic criteria were rearranged into two areas: 1) social communication/interaction, and 2) restricted and repetitive behaviors). Thus, the aforementioned changes were taken into consideration in this 20+ year review, and the initial search term “autism” was translated into the following pool of related and extended search terms: “autism,” “Asperger,” “ASD,” “PDD,” and “PDD-NOS.”

Regarding the second term, “virtual reality,” there are also numerous definitions and approaches to what constitutes virtual reality. Nevertheless, the following and recent definition of virtual reality was selected from the website merriam-webster.com (Merriam-Webster, 2015) as it was both clear and condensed: “an artificial environment which is experienced through sensory stimuli (as sight and vision) provided by a computer and in which one’s actions partially determine what happens in the environment.” Thus, initially, the aforementioned search term “virtual reality” was translated and expanded into the following related search terms: “virtual,” “reality,” “environment,” “VR,” “VE,” and “VLE.”

Following the initial selection of the search terms for both “autism” and “virtual” reality and their extended search terms, search results revealed a need for a revision of the search terms. More specifically, and in regard to “autism,” the search term “PDD-NOS” was rejected as the search term “PDD” was sufficient. Also, the search terms “autistic” and “ASC” were added as some search engines would provide different results when the search term “autistic” was inserted instead of “autism,” and a few yet noteworthy articles used the term “ASC” instead of “autism” or “ASD.” Therefore, the finalized group of search terms for “autism” consisted of the following six search terms: 1) “autism”; 2) “autistic”; 3) “Asperger”; 4) “ASD”; 5) “PDD”; and 6) “ASC.”

Respectively, and in regard to “virtual reality,” the search terms “reality” and “environment” were rejected, as they do not pertain solely to or are not unique to virtual reality. On the other hand, the search terms “avatars,” “worlds,” “immersion,” “immersive,” and “MUVEs” were added. Thus, the finalized group of search terms for “virtual reality” consisted of the following eight search terms: 1) “virtual”; 2) “avatars”; 3) “immersion”; 4) “immersive,” 5) “MUVEs,” 6) “VR”; 7) “VE”; and 8) “VLE.” The findings and results of this systematic literature review are based on the aforementioned six and eight search terms. Their respective 1:1 Boolean combinations were applied systematically to electronic academic databases, independent peer-reviewed publishers, and online reference systems.

4.6.2 Search strategy and terms

A search strategy biased toward sensitivity (retrieving a high proportion of relevant studies) rather than specificity (retrieving a low proportion of irrelevant studies) was employed due to concern about a small number of available articles (Duffield et al., 2018; Uman, 2011). A comprehensive list of high and low-yield search terms was developed (Duffield et al., 2018). Regarding the high-yield search terms, these were terms that yielded similar search results (Duffield et al., 2018). For example, a search for “virtual” also includes results for “virtual reality”

(Duffield et al., 2018). As previously mentioned, application of these criteria resulted in the retention of six condition terms (i.e., 1) “autism”; 2) “autistic,” 3) “Asperger”; 4) “ASD”; 5) “PDD” and 6) “ASC”), and eight exposure terms (i.e., 1) “virtual”; 2) “avatars”; 3) “immersion”; 4) “immersive,” 5) “MUVEs,” 6) “VR”; 7) “VE”; and 8) “VLE”) (Duffield et al., 2018).

Boolean combinations were used with binary combinations of one autism-related search term and one virtual reality-related search term (for example, “autism” “AND” “virtual reality”). The same search strategy was used and systematically applied across all databases. The search process started with broad search terms such as “virtual OR VR” and “autism OR autistic OR ASD” and “immersion OR immersive. We then proceeded with more specific terms, such as “Asperger,” “ASC,” “avatar,” and “MUVEs,” among others.

4.6.3 Databases

For the needs of this systematic review, a comprehensive literature search was performed. The following 18 online academic databases with interdisciplinary indexes were used to retrieve relevant literature: 1) Association for Computing Machinery Digital Library (ACM Digital Library), 2) EBSCOhost, 3) Elsevier, 4) Emerald, 5) Education Resources Information Center (ERIC), 6) Institute of Electrical and Electronics Engineers Xplore Digital Library (IEEE Xplore Digital Library), 7) IGI Global, 8) Mary Ann Liebert, 9) Massachusetts Institute of Technology Press (MIT Press), 10) ProQuest, 11) PubMed, 12) SAGE Journals, 13) Science Direct (SciVerse), 14) Scopus, 15) SpringerLink, 16) Taylor & Francis Online, 17) Wiley Interscience, and 18) WilsonWeb. The aforementioned databases were chosen due to their powerful search engines that enable searches across sets of terms to be combined and updated, thereby narrowing the list of possible articles for inclusion. Furthermore, they contain numerous publications regarding pertinent research (e.g., educational, biomedical, psychological, technological), have millions of citations altogether, and overall provide thorough coverage and comprehensive indexing of the journals, books, and proceedings in the sciences, social sciences, arts, and humanities fields (Mesa-Gresa et al., 2018).

Lastly, it is noted that the researcher attempted to run the search in other databases (such as Google Scholar), but their search engines did not allow terms to be combined in a way suitable for this review. Additionally, the researcher chose not to include grey literature, as its diverse and heterogeneous body of material is made public outside and is not subject to traditional academic peer-review processes (Adam et al., 2017). Thus, and in an effort to maintain this systematic literature review as rigorous as possible, peer-reviewed publications (full online papers) were selected.

4.6.4 Inclusion and exclusion criteria

Next, the inclusion and exclusion criteria (Table 4.1) were established for selecting studies in this literature review (Duffield et al., 2018).

Table 4.1 Literature review: inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
The following were *included*: peer-reviewed journals; English-language journals; qualitative & quantitative empirical studies; studies aiming intervention (training/treatment)	The following were *excluded*: dissertations and theses; book chapters; brief reports (6 pages and under); posters and editorials; theoretical approaches; Augmented Reality studies (AR), and reviews

Before beginning the literature search, the types of documents (i.e., full online articles) to be included in the review and the search terms to locate them were established. Titles and abstracts of each article were evaluated to determine whether they met the criteria for inclusion, followed by a full-text review to assess if criteria were met for inclusion in this review (Duffield et al., 2018). Also, it is noted that this process was performed by the author/researcher who solely screened the articles. Thus, inter-rater reliability for the study selection could not be reported at this time, and possible selection bias should be noted. Nonetheless, in an effort to minimize bias, the researcher received pertinent training, used high-yield search terms, employed inclusion/exclusion criteria commonly found in the literature, and assessed the quality of the identified studies.

4.7 Step 3: Assessing the study quality

For the quality assessment of the identified studies, a process similar to the one described in Heitink et al. (2016) was followed. In their study, Heitink et al. (2016) employed a total of 11 questions from 5 categories (general, selection sample, method, data analyses, and conclusion). Due to the significant heterogeneity of the studies in the VR-autism literature and efficiency reasons, our quality check consisted of 5 questions out of the 11 questions used by Heitnick's team, one for each respective category. The questions can be found below (Table 4.2). The assessment of the studies' quality was solely performed by the author/researcher during the study selection process. Thus, inter-rater reliability could not be reported at this time, and possible bias should be noted. Nonetheless, and in an effort to minimize bias and ensure inclusivity, the researcher employed closed-ended quality questions as found in the pertinent literature.

Table 4. 2 Quality questions

Category	**Quality questions**
General	Is the research objective clear?
Selection sample	Is the context of the research clear?
Method	Do the researchers describe the research methods used?
Data analysis	Are the results presented clearly?
Conclusions	Is the research question answered using gained empirical evidence?

4.8 Step 4: Summarizing the evidence

Appendix B summarizes the articles of this literature review.

4.9 Step 5: Reporting the findings

Below are the findings for each of the questions posed for this literature review.

4.9.1 SR-Q1: What affordances (design guidelines) are used?

Studies reveal diversity in the design guidelines (affordances) used for the design of virtual environments for individuals with autism. The following VR affordances were noted: real-time interaction (e.g., Wade et al. 2016; Zhang et al., 2017; Self et al., 2007; Lorenzo et al., 2016; Halabi et al., 2017; Parsons et al., 2005; Smith et al., 2020), 1st user point of view (e.g., Lahiri et al., 2015; Lahiri et al., 2011), avatars (Wang et al., 2018; Laffey et al., 2014; Stichter et al., 2014; Wang et al., 2017; Schmidt et al., 2014;), and immersion/presence (e.g., Wade et al., 2017; Zhang et al., 2017; Self et al., 2007; Kim et al., 2015; Bekele et al., 2014; Lorenzo et al., 2016; Kuriakose and Lahiri, 2017; Parsons et al., 2006; Mitchell et al., 2007; Josman et al., 2008; Trepagnier et al., 2011; Strickland et al., 2013; Kandalaft et al., 2013; Didehbani et al., 2016; Ke & Im, 2013; Ke et al., 2015; Bozgeyikli et al., 2017; Strickland, 1997; Cheng et al., 2015).

4.9.2 SR-Q2: What VR technologies are utilized?

Researchers report that a variety of VR technologies are being utilized for training various skills in individuals with autism: desktop (e.g., Wade et al., 2016; Kim et al., 2015; Bekele et al., 2014; Bekele et al., 2012; Kuriakose and Lahiri, 2017; Halabi et al., 2017; Parsons et al., 2006; Mitchell et al., 2007; Josman et al., 2008; Trepagnier et al., 2005; Grynszpan et al., 2012; Wang et al., 2018; Laffey et al., 2012; Stichter et al., 2014; Parsons, 2015; Strickland et al., 2013; Kandalaft et al., 2013; Didehbani et al., 2016; Ke & Im, 2013; Ke et al., 2015;), HMD (e.g., Bozgeyikli et al., 2017; Strickland, 1997; Cheng et al., 2015; Jarrold et al., 2013), CAVE (e.g., Lorenzo et al., 2016; Halabi et al., 2017; Ip et al., 2018), and projector (e.g., Cai et al., 2013; Lu et al., 2018; Jung et al., 2006).

4.9.2 SR-Q3: What skills are targeted?

The following skills were found to be targeted in the developed virtual environments for individuals with autism: social skills (e.g., Parsons, Mitchell, and Leonard, 2005; Parsons, Leonard, and Mitchell, 2006; Cheng, Ke et al., 2015; Kuriakose, and Lahiri, 2015; Zhao et al., 2016; Bekele et al., 2016; Beach and Wendt, 2016; Kim et al., 2015; Kuriakose and Lahiri, 2016; Didehbani et al., 2016; Parsons, 2015; Cheng, Huang, and Yang, 2015; Ip et al., 2016; Ip et al., 2018; Wang et al., 2017; Wallace, Parsons, and Bailey, 2017), daily living/functional skills (e.g., Self et al., 2007; Josman et al., 2008; Wade et al., 2015; Zhang et al., 2015a; Wade et al., 2016; Cox et al., 2016; Zhang et al., 2017; Smith et al., 2014; Lamash, Klinger, and Josman et al., 2017), communication skills (e.g., Lahiri et al., 2015; Kuriakose and Lahiri, 2016; Georgescu et al., 2014; Halabi et al., 2017; Wang et al., 2017; Tartaro and Cassell, 2008; Schmidt and Beck, 2016; Forbes, Pan and Hamilton, 2016; Root et al., 2017), emotional skills (e.g., Lorenzo et al., 2016; Chevalier et al., 2017; Ip et al., 2018), behavioral skills (e.g., Ramachandiran et al., 2015), and sensory skills (e.g., Jung et al., 2006; Bozgeyikli et al., 2016).

The literature review revealed the heterogeneity among the studies regarding the participants, the VR technologies used, and the virtual applications (environments) developed. Differences among the studies are expected, as the autism population is diverse and each research study has a different aim (i.e., targeting a different set of skills while using a different VR technology/environment). Nonetheless, it seems that the lack of a common framework for something as fundamental as the VR definition, the taxonomy of VR systems/types, the VR affordances, and design guidelines for VEs has led to significant inconsistencies in the use of terms, approaches, and even interpretations of findings. This appears to hinder the establishment (or working towards that direction) of VR as an evidence-based intervention for individuals with autism, as opposed to the current perception of it being a technology with great potential.

4.10 Current Delphi research for autism and virtual reality

Pertinent literature appears to be quite limited, including two seemingly related publications by Ghanouni et al. (2017) and Ghanouni et al. (2018) on a Delphi study for autism and virtual reality. In 2017, Ghanouni et al. presented their study for the first time in a brief conference article. It aimed to use the Delphi technique to reach a consensus on a selection of social stories that would be included in a 3D VR game for children with autism. The VR game, which was not designed at the time, would be used to teach socio-emotional skills (e.g., requesting from peers/adults, conflict management, and group collaboration for task completion) to children with autism. Nonetheless, the researchers developed over 60 social stories that would comprise the content of the 3D VR game. Fifty stakeholders (22 clinicians and 28 parents of children with autism) were considered to be "experts" in autism and participated in the Delphi study. The panelists were asked to provide feedback regarding the content of the social stories scenarios and reach a consensus on which social stories to include in a VR game. Two rounds of online questionnaires were employed, and 90% of VR scenarios reached an 80% agreement level for acceptance in the VR game (i.e., three scenarios were excluded). The scenarios that reached consensus were revised based on feedback from stakeholders. The research team reported, "these scenarios and story package will be used in the development of the virtual reality program where we will collaborate with computer science engineers." Lastly, Ghanouni et al. (2017) anticipated that their client-centered approach and incorporation of stakeholders' input for the development of their VR game for children with autism would facilitate their participation in everyday tasks and communication interactions.

In the 2019 publication, Ghanouni et al. present a (seemingly) more detailed and updated description of their 2017 study or its continuation, if not even re-administration. There is no explicit mention of the 2017 study in their more recent 2019 paper. However, the authors state, "First, we shared with our steering committee the scenarios we developed according to the ideas gathered from focus groups with stakeholders held in previous phases of the study and based on the literature (Golan et al. 2010; Bernad-Ripoll 2007; Rao et al. 2008). Any comments related to rephrasing the stories or changing the terms were addressed prior to the validation process. Next, participants were provided with those scenarios in the online survey" (p. 3). Although both publications share significant similarities, there are some methodological differences - for example, the 2019 publication reports 63 participants, 75 short socio-emotional stories, and a 75% level of consensus, making it somewhat unclear exactly how the two studies correlate. Lastly, regarding the 3D VR game, it appears that it has not been designed, and there are only various mentions of accepted social scenarios to be tested and used as content for a virtual reality program.

4.11 Aim of the study

This study aimed to propose design guidelines for virtual environments for individuals with autism. Its significance lies in three basic questions:

- Why is autism research important?
- Why are Virtual Reality and design guidelines significant in autism research?
- Why use a Delphi study?

Next, we will present arguments for each of these questions in an effort to provide a well-rounded approach to this study's aim and purpose.

4.11.1 Why is autism research important?

Thurm and Swedo (2012) provide a well-rounded approach to the significance of autism research. Autism, being a spectrum disorder (Wing, 1993) that is behaviorally defined as a "pervasive developmental disorder" (Thurm and Swedo, 2012), is characterized by a series of lifelong deficits. These deficits include difficulties in social communication, the presence of restricted interests, repetitive behaviors (Thurm and Swedo, 2012), and comorbid disabilities such as cognitive disorders (Wing and Gould, 1979). Deficits in autism significantly affect individuals' everyday and independent living (Glaser et al., 2021). There is a plethora of studies that advocate the need for interventions in autism. A lack of support in affected areas can lead to difficulties with social interactions and establishing relationships with peers, as well as (increased) unemployment (Glaser et al., 2021; Frith and Mira, 1992; Eaves and Ho, 2008). Thus, there are significant and lifelong educational, community, and financial consequences that require attention (Thurm and Swedo, 2012).

After autism's identification as a disorder with neurodevelopmental origin, research and literature emerged and highlighted educational, technological, and behavioral interventions providing potential benefits. The paradigm shift also opened new pathways for studying the etiology, etiopathogenesis, and treatment of autism. Virtual reality is one of the most innovative and recent treatment approaches for autism. Novel therapies and interventions can be tested in larger populations to facilitate replication, potentially enabling the generalization of their findings. This can be beneficial and applicable also for various genetic and non-genetically based neurodevelopmental disorders with similar characteristics to those found in autism. Thus, autism research can help to understand and identify its commonalities, etiology, basic developmental process, and potential interventions, and understand (Thurm and Swedo, 2012).

Regarding the prevalence of autism, it has been rising significantly in the last two decades and reportedly affects 1 in 59 children in the United States (Baio et al., 2018). There is an estimate of more than 2 million individuals in the US with autism (Thurm and Swedo, 2012). With autism prevalence increasing, so does the need and search for efficacious treatments (Thurm & Swedo, 2012). To date, there are no preventive strategies that have consistently demonstrated benefits. There are also no treatments with widespread and proven efficacious results for the core symptoms of autism (Thurm and Swedo, 2012). Despite several studies, pertinent outcomes are somewhat poor (Glaser, 2021; Billstedt, Gillberg and Gillberg, 2005; Eaves and Ho, 2008; Howlin et al., 2004; Parsons, 2016). Nonetheless, there is evidence-based behavioral interventions (Bogin, 2008) found in pertinent literature that additionally support the use of technology (instruction/training) (Glaser, 2021). Virtual reality is increasingly identified as a "potentially efficacious" technology for individuals with autism (Glaser, 2021; Aresti-Bartolome and Garcia-Zapirain, 2014).

4.11.2 Why are Virtual Reality and design guidelines significant in autism research?

As previously mentioned, relevant literature and studies report that virtual reality has the potential to support the social, communication, and daily living/functional needs of individuals with autism therapeutically and educationally (Glaser, 2021). Virtual reality appears to be a promising technology for individuals with autism. It offers visually stimulating and appealing environments (Schmidt et al., 2019) and learning affordances that complement the learning needs of individuals with autism (Glaser, 2021; Conway, Vogtle and Pausch, 1994; Dalgarno and Lee, 2010; Parsons, 2016; Glaser and Schmidt, 2018). Reported benefits of using virtual reality include, among others, realism, immersion, controllability (system, variables, complexity), predictability (task, scenarios/narrative), feedback, and reinforcement (Glaser et al., 2021; Bozgeyikli et al., 2018).

Nonetheless, as like with many interventions for autism, there are significant challenges that the design and development of relevant tasks entail. Each individual has a unique clinical profile, i.e., needs, strengths, and weaknesses. Thus, an interdisciplinary approach (e.g., clinicians, educators, researchers, software engineers) is required to address the design complexities (Glaser, 2021). Currently, there are no universally accepted design guidelines for designing virtual environments tailored to individuals with autism. Moreover, each research team and project employs different design principles and guidelines, which can often be unclear to the reader. Thus, a closer look into the design guidelines for virtual environments tailored to individuals with autism could be beneficial and contribute to positive outcomes for the users. Lastly, with the introduction and consideration of the neurodivergent model, a new perspective on traditional approaches has emerged. Virtual reality can offer the flexibility and fluidity to accommodate various treatment approaches while being inclusive and adaptive to new models/theories.

4.11.3 Why use a Delphi study?

Current educational developments, healthcare breakthroughs, and technological innovations are going hand in hand with a continuously evolving research landscape for practitioners, providers, and researchers (Nworie, 2011). With a wide array of research methodologies available to researchers from different disciplines, including autism and virtual reality, the Delphi technique offers many benefits (Nworie, 2011). These benefits include the ability to obtain an expert opinion, build consensus, determine the suitability of the application of (instructional/teaching/training) interventions, forecast future trends/directions, determine a course of action, provide leadership with information for decision-making, policy formulation, or improvement of practices in the field (Nworie, 2011; Bickel, 1998; Bornyas, 1995; Rines, 1988; Scarpa, 1998). Furthermore, the technique can be used in various settings, and the interactions with participants are not limited by time and space (Nworie, 2011). This was especially helpful in our study, as we were able to connect and bring together experts from around the world using modified versions of e-Delphi.

Furthermore, the use of an e-Delphi study represents an innovative and user-friendly approach to an existing forecasting method. It is less labor-intensive than a traditional method, as it is not paper-reliant (eco-friendly), retains the essence of traditional methods, but speeds up the execution process while capitalizing on efficiency and utilizing the benefits of a web-based research tool (Chou, 2002, p. 236).

Currently, research in autism and virtual reality applications is considerably heterogeneous in terms of the research teams (with various educational and experiential backgrounds) and the studies themselves. The literature review of pertinent published studies revealed significant diversity in participants, research designs/methodologies, information reported, results explained, VR technologies used, and VR applications designed. In the majority of the studies, the principles and guidelines on which the developed virtual environments/applications were based.

They also often do not report or propose guidelines, although many of them suggest benefits and comment on the potential of the use of VR in autism.

Thus, the Delphi technique could help identify new directions and best practices regarding the design guidelines for virtual reality environments that are more likely to benefit individuals with autism (Nworie, 2011). The Delphi methodology is designed to both obtain and identify areas of consensus and divergence of opinion (Nworie, 2011). The Delphi methodology is an effective approach in cases involving a problem for which the application of analytical techniques is not easily feasible, but which can benefit from subjective judgment (Nworie, 2011). The Delphi technique can be useful when investigating problems with multiple issues and requires the judgments of expert panelists. Its approach is based on the notion that the collective viewpoints of expert panelists can yield better results than the limited view of an individual (Nworie, 2011). Thus, the Delphi technique can be a beneficial tool in the field of educational technology (Nworie, 2011).

Chapter 5

METHODOLOGY AND MATERIALS

5.1 Introduction

As previously mentioned, it appeared that there was no common ground among the experts regarding the design guidelines for virtual reality environments for individuals with autism. Thus, this Delphi study was undertaken to identify and gain consensus on this matter (Keeney, McKenna and Hasson, 2011, p.142).

Regarding Delphi studies, Keeney, McKenna and Hasson (2011) note: "We predict that more Delphi studies specifically and survey generally will be carried out by electronic means" (p. 150). Per Chapter 3, 'e-Delphi' involves the administration of the classical Delphi via e-mail or through the completion of an online form (Avery et al., 2005). Keeney, McKenna and Hasson (2011) also add that: "[...] 'Survey Monkey' is becoming increasingly popular and is replacing the postal questionnaire" (p. 150). Our Delphi study was international, and therefore, it was not possible for participants to meet face-to-face in a consensus conference or to participate in nominal groups. Thus, the e-Delphi approach was selected as an appropriate and relevant research approach. We also opted for SurveyMonkey® for the design and development of each round's questionnaire.

5.2 Classical Delphi as a foundation for e-Delphi

Keeney, McKenna and Hasson (2011) provide a concise and indicative summary of the classical Delphi method. Their description reflects the process followed in our study, with classical Delphi being the foundation of an e-Delphi, including ours (p.6): "Its original form, known as the classical Delphi, involves the presentation of a questionnaire to a panel of 'informed individuals' in a specific field of application, to seek their opinion or judgment on a particular issue. After they respond, the data are summarized, and a new questionnaire is designed based solely on the results obtained from the first round. This second instrument is returned to each subject, and they are asked (in the light of the first round's results) to reconsider their initial opinion and to return their responses once again to the researcher. Repeat rounds of this process may be carried out until a consensus or a point of diminishing returns is reached. This illustrates that the Delphi technique is a multi-stage approach with each stage building on the results of the previous one. Hitch and Murgatroyd (1983) saw it resembling a highly controlled meeting of experts, facilitated by a chairperson who is adept at summing up the feelings of the meeting by reflecting the participants' own views to them in such a way that they can proceed further – the only difference is that the individual responses of the members are unknown to one another "(Keeney, McKenna and Hasson, 2011, p.6).

5.3 In preparation for the study

Online questionnaire platform

Regarding the identification and selection of the appropriate online platform for designing and developing the study's questionnaire, literature research revealed that the main platforms used were Google Forms, SurveyMonkey® , and platforms designed specifically for the needs of each study. In our case, SurveyMonkey®, "an online survey development cloud-based software" (www.surveymonkey.com), was selected due to its ease and wide use. Additionally, SurveyMonkey® offers an array of tools and functions for questionnaire design, development, and data collection, processing, and presentation.

Initial electronic communication with experts

Regarding the assembly of the study's panel of experts, an initial sample of potential experts was identified through a literature review and snowball sampling. Potential experts who met our study's eligibility criteria were sent an introductory email that included a brief overview of the study, incentives for their participation, and the researcher's intention to invite them to participate in this study, along with next steps. This initial preparatory step of the study was fundamental for establishing a first connection and acquaintance with the experts. It could also improve the chances of visibility for the official invitation to the study email (and therefore, experts' participation). It also allowed experts and the researcher to address any initial questions that arose. It also resulted in unsolicited snowballing, expression of interest, and, in some cases, even commitment for experts' participation. Lastly, it identified any technical difficulties, such as emails that were not delivered (e.g., invalid email addresses, firewall protections), and determined the optimal/preferred contact information for experts. Thus, the researcher had the opportunity to address these issues before sending the official email invitation to the study's experts.

5.4 Delphi participants

Delphi samples vary and depend on the study's purpose and selected design (Jairath and Weinstein, 1994). It is important to ensure the participation of experts who have knowledge, understanding, and diverse viewpoints on the issue under study (Czinkota and Ronkainen, 1997). The composition of the sample is related to the validity of the research results (Spencer-Cooke, 1989). Therefore, considerable attention needs to be given to issues related to sampling and selection, as it should not be random. Non-probability sampling techniques can be used individually or in combination (e.g., convenience and snowballing to recruit the sample). Thus, and like in our study, panel members were identified through literature searches and/or recommendations from other recognized experts in the field (Gordon, 1992) as "such approaches are often adopted when the research population is hard to identify (Polit & Hungler, 1999) (Keeney, McKenna and Hasson, 2011, p. 57)".

5.4.1 Eligibility criteria

As previously mentioned, and in preparation for this study, a rigorous process was undertaken to identify potential experts. This aimed to establish a panel of individuals who should be considered 'experts' in their field (Keeney, McKenna and Hasson, 2011; Hicks, 1999). Potentially participating experts would have ‘objective expertise’, i.e., “knowledge gained due to academic position, education and research” Shariff, 2015, p. 3).

Potential interdisciplinary panel members were identified through an extensive review of relevant literature and snowball sampling. There was no requirement for prior knowledge, experience, and/or participation in a consensus study. Thus, two sets of eligibility criteria were developed for the literature review sample and the snowballing sample, respectively:

- *Literature review participants* - Identified potential experts had to meet all the following eligibility criteria to be considered eligible panel members and thus invited to participate in the study:
    - Empirical published research in virtual reality and autism.
    - Pertinent publications(s) in peer-reviewed journals.
    - Pertinent publications in English and international journals.
- *Snowballing participants* - Once referees provided adequate justification for their recommendation, the identified potential experts had to meet at least one of the following criteria to be eligible panel members and thus invited to participate in the study:
    - Empirical peer-reviewed international publication(s) in English and in virtual reality and/or autism.
    - Empirical research in virtual reality and/or autism.
    - Experience/knowledge in the fields of virtual reality and/or autism.

5.5 Setting a consensus level

For this study, the consensus level on each item was equated with at least 75%. This was deemed adequate, as Keeney, McKenna and Hasson (2011) and McKenna et al. (2002) had suggested that 70% was a strong cut-off point. Furthermore, the consensus level was used for items in the study’s Round 3. A total of 8 experts participated in that round; thus, the selected consensus level would reflect the opinion of each individual as a singular entity (as opposed to a “partial representation” of each panelist). Items in Round 3 that experts rated below this level were excluded from the list of suggested design guidelines for virtual reality environments for individuals with autism.

5.6 Pilot and mini pilot study

The members of the pilot study were expected to complete each round's questionnaire. They would then provide their feedback/input about the questionnaire's instructions and questions. The queries pertained to the questionnaire's design, layout, clarity of information, content, completion time, ease of use, ergonomics, and overall efficiency. After receiving the team's feedback, changes and adjustments would be made to the questionnaire as needed. Overall, once the members felt that the questionnaire was well-structured, clear, and concise, it was administered to the panel of experts.

It is noteworthy that because members were asked to review the same questionnaire at least twice, this contributed to the questionnaire's reliability. In addition, members reported that the structure and content of the questionnaires overall assisted them provide targeted/specific responses without feeling constrained. Also, members stated that they were able to identify 'design guidelines' (i.e., relevant benchmarks) which contributed to content validity.

5.6.1 Mini pilot study

Following that step, a mini-pilot study would be conducted with some of the participants from the pilot study. The members of the mini pilot study reviewed the revised questionnaire to ensure that feedback was accurately captured. Once that last check was completed, the final questionnaire would be administered to the panel of experts. It is noted that the mini pilot study would include 2-3 members of the (main) pilot study. In a triangulation approach, these members would be a) the individual(s) who suggested the changes, b) the member that met the expert panel's eligibility criteria for the literature review sample, and c) on an as needed basis, one member from a different discipline than the one of the member(s) suggesting the changes to the questionnaire.

5.6.2 Member recruitment

Green, Tull and Albaum (1988) and Reynolds, Diamantopoulos and Schlegelmilch (1993) suggest that a pilot study's sample should be small enough to cover all subgroups of the target population. In our study, pilot study participants, identified through snowball sampling, were contacted and informed by the researcher about the study's purpose. They were also provided with details about their role and responsibilities as members of the pilot study team. Once they accepted the invitation for the pilot study, the members committed to their participation throughout it.

5.6.3 Panel size

Pertinent literature references generally small pilot testing samples, ranging from 5-10 to 50-100, depending on the author(s) concerned. The exact size of the pilot study sample depends on the variety of respondents in the final study. It should be sufficient to consider and satisfy the similarity to the targeted expert panel, the variety of respondents, and the complexity and uniqueness of the questionnaire (Tull and Hawkins, 1987; Reynolds, Diamantopoulos and Schlegelmilch, 1993). Hunt, Sparkman and Wilcox (1982) and Reynolds, Diamantopoulos and Schlegelmilch (1993) state that the sample size is a function of the instrument and the target population.

Thus, in our study, each round's questionnaire was pilot tested with five individuals/professionals. These individuals were from outside the research setting to ensure content and face validity. As the research field of ASD and VR is somewhat narrow, snowball sampling was used to recruit participants for the pilot study. The identified five individuals had different and diverse educational backgrounds that represented the main educational backgrounds of the experts (i.e., Computer Science/Engineering, Educational Technology, Physics/Mathematics, Medicine, and Special Education). In addition, one of the pilot study's participants met the eligibility criteria of the literature expert sample. Each participant was knowledgeable regarding ASD, VR, or both.

5.6.4 Means

Although it is not possible to detect all types of defective questions through pretesting, the questionnaire pretesting methodology can be employed to identify question phrasing problems, rather than question-sequencing problems (Bolton, 1991; Reynolds, Diamantopoulos and Schlegelmilch, 1993). Additionally, relevant literature suggests that pretesting of a questionnaire is often conducted through personal interviews (Boyd, Westfall and Stasch, 1989; Reynolds, Diamantopoulos and Schlegelmilch, 1993). This way, the interviewer can observe the respondents as they fill in the questionnaire. Also, personal interviews are recommended at least in the pretesting phase, whereas the final phase of pretest could use the same medium as the one used for the study (Peterson, 1988; Kinnear and Taylor, 1987; Boyd, Westfall and Stasch, 1989; Reynolds, Diamantopoulos and Schlegelmilch, 1993). Regarding the respondents' responses to the questionnaire, respondents can either think out loud (protocol method) as they complete the questionnaire or discuss it after its compilation (debriefing method).

Additionally, normative literature suggests that personal interviewing is more effective than telephone interviews for detecting and identifying design errors in questionnaires. Nonetheless, Hunt, Sparkman and Wilcox's (1982) and Reynolds, Diamantopoulos and Schlegelmilch's (1993) state that both personal and telephone interviewing could equally identify study errors. Also, personal interviews (store protocols) were found to be more effective at detecting missing alternative errors. Whereas, (store) debriefing was better on double and ambiguous questions. Lastly, telephone protocols were found to be more effective than both personal interviews and debriefing in terms of the average detection rate.

In pretesting, protocols or debriefing can be employed using the final study method or interviews (in-person and over the phone); differences in the effectiveness of the possible combinations and between protocol and debriefing require further investigation. Additionally, the various combinations of interview methods and media require further exploration. According to Hunt, Sparkman and Wilcox (1982) and Reynolds, Diamantopoulos and Schlegelmilch (1993), telephone protocol interviews had the highest average error detection rate. On the other hand, normative literature supports the use of personal interviews when the final study method is not being used for the pretest (or even as an alternative to the final study method).

In our pilot studies, personal and/or telephone interviews, along with the effective debriefing method, were employed. Regarding debriefing and lengthy questionnaires like ours, a concern highlighted in the literature is that problems encountered at the beginning of the questionnaire may be overshadowed by those encountered towards the end. To overcome this, the interviewer/researcher meticulously asked the pilot study participants for their input on all sections of each round's questionnaire.

5.6.5 Pilot study's interviewer

Pretesting examines respondents' reactions to the questionnaire, as well as potential problems encountered by the interviewers (Tull and Hawkins, 1990; Reynolds, Diamantopoulos and Schlegelmilch, 1993). Some researchers (Hague 1987; Kinnear and Taylor 1987; Boyd, Westfall and Stasch 1989; Reynolds, Diamantopoulos and Schlegelmilch 1993) recommend that experienced interviewers administer pretests, as they would likely document better the respondents' reactions. On the other hand, other researchers suggest that a range of interviewing experiences would be appropriate (Tull and Hawkins, 1987, 1990; Hunt, Sparkman, and Wilcox, 1982; Worcester and Downham, 1986; Reynolds, Diamantopoulos, and Schlegelmilch, 1993). Nonetheless, the level of the interviewer's experience is often left to the researcher's judgment, based on the pretest's aim and the complexity of the administered questionnaire (e.g., an experienced interviewer is expected to identify more errors in a complicated questionnaire compared to a less experienced or even inexperienced interviewer).

Moreover, pertinent literature (Tull and Hawkins, 1990; Reynolds, Diamantopoulos and Schlegelmilch, 1993) also suggests that the responsible researcher (the project's director) is directly involved in the interview process at the pretest stage. The rationale for this is that the responsible interviewer would have a better understanding of the issues associated with the questionnaire and its administration. In our study, the researcher served as the interviewer and had previous hands-on experience in clinical and research interviews.

5.7 Round 1

5.7.1 Pilot and mini pilot study

Initially, and for Round 1, the researcher created a draft questionnaire using the online survey tool SurveyMonkey®. The draft questionnaire was pilot tested before its final distribution to the expert panel. The pilot testing aimed to determine the questionnaire's potential effectiveness, refine its design, and identify errors that may only be apparent to the targeted population (e.g., specific word meanings). The dry run of the pilot testing process (Hunt, Sparkman and Wilcox 1982; Reynolds, Diamantopoulos and Schlegelmilch, 1993) included the assessment of the individual administered questions as well as the questionnaire's overall logical sequence (flow), layout (color, fonts, emphasis, etc.), instructions (language, clarity, consistency, coherence, appearance), and any branching or skipping patterns (Oppenheim 1966; Reynolds, Diamantopoulos and Schlegelmilch, 1993). Based on the feedback received from the pilot testing of Round 1's questionnaire, minor wording and layout changes were made to the questionnaire. After incorporating members' feedback into the questionnaire, a mini-pilot study was conducted. The participating members of the mini-pilot study reported no additional concerns/comments regarding the updated questionnaire, stating that it accurately reflected their feedback. The final questionnaire was then administered to the expert panel.

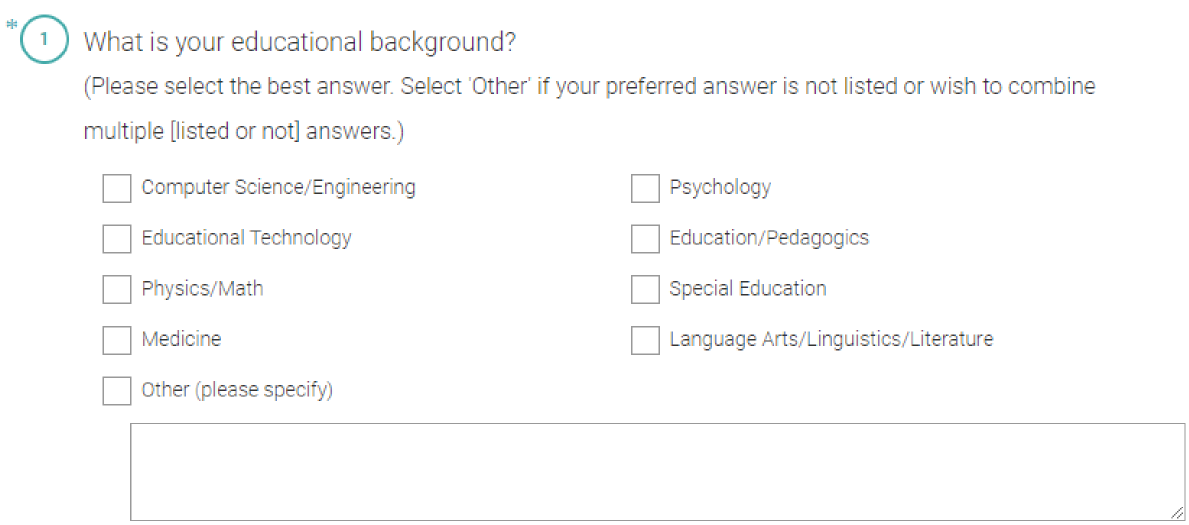
5.7.2 Questionnaire

The Round 1 questionnaire (Appendix C) consisted of three sections. The first section included instructions for completing the questionnaire. The second section comprised five demographic questions, and the third section consisted of five open-ended questions related to key study areas.

In the second section of the questionnaire, five closed-ended demographic questions asked panelists for their educational background, current professional position, work setting, geographic location, and experience (Table 5.1, Figure 5.1). Overall, Round 1's five demographic questions are basic and typical mainstream questions derived from relevant literature related to Delphi.

Table 5.1 Round 1 Questionnaire with demographic questions
Q1: What is your educational background?
Q2: What is your current professional position?
Q3: Where is your current professional position?
Q4: In which country is your current professional position located?
Q5: How many years of experience do you have with VR, ASD, and VR & ASD?

Table 5.1 Demographic questions, Round 1 Questionnaire


* 1 What is your educational background?
(Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)

- [ ] Computer Science/Engineering
- [ ] Psychology
- [ ] Educational Technology
- [ ] Education/Pedagogics
- [ ] Physics/Math
- [ ] Special Education
- [ ] Medicine
- [ ] Language Arts/Linguistics/Literature
- [ ] Other (please specify)

Figure 5.1 Screenshot of Round-1's questionnaire, closed-ended demographic Question-1.

The questionnaire's third section consisted of five open-ended questions (Table 5.2, Figure 5.2) that aimed to capture the opinions of participating experts on fundamental issues related to the use of virtual reality for individuals with autism. The open-ended questions allowed respondents to freely generate ideas (Hasson, Keeney and McKenna, 2000) and identify as many points as they deemed important.

Table 5.2 Round 1 Questionnaire with open-ended questions
Q6: In your opinion, which VR features/characteristics can be used to benefit individuals with ASD?
Q7: In your opinion, which skills and functions would be beneficial to target in VR for individuals with ASD?
Q8: In your opinion, which activities/tasks would you design in VR, and for which skills and functions, to benefit individuals with ASD?
Q9: In your opinion, which characteristics and skills should an individual with ASD have in order to receive the most benefit from VR?
Q10: Overall, is there anything else you would like to add?

Table 5.2 Open-ended questions, Round 1 Questionnaire

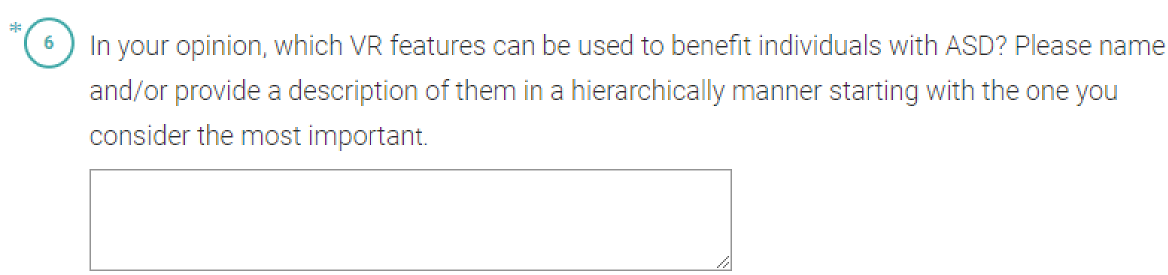


Figure 5.2 Screenshot of Round-1's questionnaire, open-ended Question-6.

With regard to the first four open-ended questions, they were broad, well-constructed, and answerable questions that followed the principles of the PICO structured format (i.e., population, intervention, comparator, outcome) and could be classified as therapy/intervention questions (IOM, 2011; Richardson et al, 1995; Counsell, 1997; Cochrane, 2021). The fifth open-ended question is broad, inviting experts to provide any additional information they deem relevant to the study.

5.7.3 Administration

After the initial introductory email was sent to the identified experts, a second email was sent to officially invite them to participate in the study. Further information about the study's purpose, outline, participation, consent, confidentiality, data protection, acknowledgement, and accessing the online questionnaire is described in detail in 'Invitation and information about e-Delphi study' (Appendix C). Additionally, just before the researcher sent their second email, another email was sent to the identified participants via the SurveyMonkey® platform; it included a link that would automatically redirect them to Round 1's online questionnaire. The panel was given ten days to complete Round 1's questionnaire. Approximately two to three days before the cut-off date, a reminder was sent via the SurveyMonkey® platform to each expert who had not completed the questionnaire. After the cut-off date, a personalized email was sent to each expert who had not submitted the questionnaire by the initial deadline, offering assistance and a ten-day extension for its completion. Similarly, a second reminder was sent before the updated due date, after which the collection of answers for Round 1's questionnaire was concluded. It is noted that following the submission of a completed questionnaire, participating experts received a personalized thank-you email for their contribution. A total of 22 experts completed Round 1's questionnaire. Similar means to support and encourage experts' overall participation, such as reminders, time extensions, and follow-up strategies (e.g., personalized emails) for non-responders, were also used in the subsequent two rounds (Keeney, McKenna and Hasson, 2011) of the study. Lastly, following the collection and process of the experts' answers, individual and group summaries were prepared and provided to the experts. As Keeney, McKenna and Hasson (2011) note, controlled feedback "allows experts to consider the group response and their own response in the light of this. It is at this point that an expert panel member may 'change' or modify their opinion, having considered the group opinion, and the panel may move towards consensus" (p.57).

5.7.4 Data collection and analysis (qualitative content analysis, inductive and deductive)

5.7.4.1 Data collection

Upon the completion and submission of Round 1's online questionnaire, the participants' answers were automatically collected and stored on the SurveyMonkey® platform. Regarding the demographic questions, the online platform provides tools for quantifying and visually representing such types of data. Thus, charts (pie charts and bar charts) were generated and utilized. Regarding the experts' answers to the open-ended questions, and similarly to the data analysis of Round 1 in the classical Delphi method, content analysis was employed. Thus, the participants' answers to the open-ended questions were content analyzed to group statements generated by the expert panel into similar areas. It is noted that SurveyMonkey® also offers limited tools for open-ended responses, including 'Analyzing Text Responses' (e.g., tagging responses, word cloud, sentiment analysis); however, due to the volume, diversity, and complexity of the data involved, these tools were not utilized.

5.7.4.2 Data analysis

Cho and Lee (note with regard to qualitative content analysis that it "involves a systematic coding process that entails finding categories and theme(s)" (2014, p.7). Furthermore, qualitative content analysis involves a data reduction process that focuses on selected aspects of the data. They also note that "Overall, the process of data analysis includes the following core steps: selecting the unit of analysis, creating categories, and establishing themes. Selecting the units of analysis is an important initial step in reduction. Researchers should decide which data to analyze by focusing on a specific aspect of the material, depending on the research questions. [...] Creating categories is a means to compress a large number of texts into fewer content-related categories. [...] (2014, p. 10) Establishing a theme is "a way to link the underlying meanings together in categories" (Graneheim and Lundman, 2004, p. 107)" (Cho and Lee, 2014, p.10).

Mayring (2000) proposed two different procedures for qualitative content analysis: inductive category development and deductive category development. According to Cho and Lee (2014), "Inductive category development consists of (p.9) a) the research question, b) the determination of category and levels of abstraction, c) the development of inductive categories from material, d) the revision of categories, e) the final working through text, and f) the interpretation of results. In deductive category development, the second and third steps are different: b) theoretically-based definitions of categories, and c) theoretically-based formulation of coding rules (Mayring, 2000, pp. 4-5)".

5.7.4.3 Qualitative content analysis

For the open-ended questions in our study, both deductive and inductive content analysis were employed. For the first open-ended question regarding the VR features/characteristics that can benefit individuals with ASD, deductive content analysis was employed. Units of analysis were selected from the experts' answers, and three main categories were determined and defined. Thus, VR systems, VR affordances, and VR learning affordances were derived from the classification framework for VR systems/types by Mikropoulos and Bellou (in press), and VR (learning) affordances by Mantziou, Papachristos and Mikropoulos (2018). According to the classification by Mikropoulos and Bellou (in press), there are six VR systems/types: QuickTime VR, Semi-immersive VR, Augmented Reality, Desktop VR, MUVEs/VWs, and Fully-immersive VR. Among the six, five were used in our study (i.e., Semi-immersive VR, Augmented Reality, Desktop VR, MUVEs/VWs, and Fully-immersive VR). It is noted that these five categories were not divided into other subcategories. Next, the researcher coded all answers/text that appeared to describe the following categories: Semi-immersive VR, Augmented Reality, Desktop VR, MUVEs/VWs, and Fully-immersive VR, according to predetermined categories. Some categories were somewhat revised, but none were removed/added during this procedure. Additionally, all data could be coded into one of the predetermined categories; therefore, there was no need to create new categories for data coding. Finally, the researcher compared the contents of the categories across all VR features/characteristics. Figure 5.3 shows the procedures of deductive qualitative content analysis for the first open-ended question of Round 1.

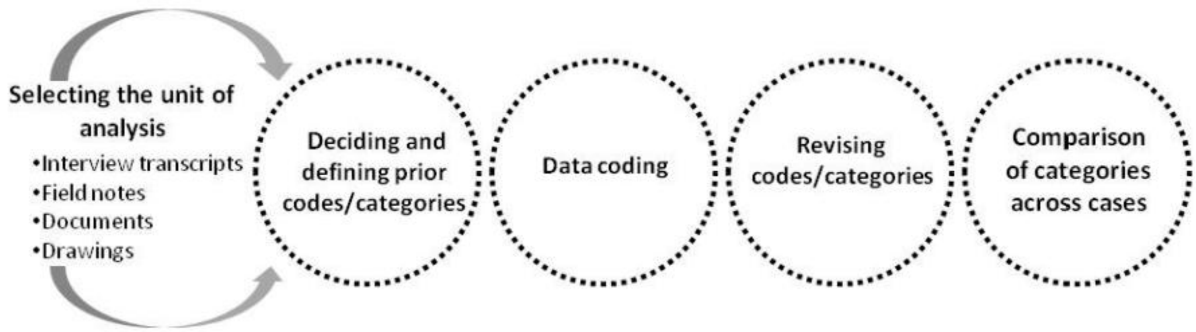


Figure 5.3 Procedure for a deductive approach to qualitative content analysis.

(Source: Cho and Lee, 2014, p.11)

To answer the following three open-ended questions, targeted skills, VR tasks, and an individual's skill set, an inductive approach to qualitative content analysis was employed. Text was extracted from the experts' answers to identify targeted skills, VR tasks, and individual skills, and then synthesized to establish the units of analysis. Open coding started by reading each answer word by word and line by line. After completing the open coding, the preliminary codes were determined as they emerged from the text, and then the remaining answers were coded using those codes. All encountered data fitted an existing code; thus, no new codes needed to be added.

The following steps involved grouping similar codes and categorizing them. Categories were reorganized into broader, higher-order categories, then grouped, revised, and refined, and finally checked to determine whether the categories were mutually exclusive. At that point, final categories were formed. Figure 5.4 shows the procedure of inductive qualitative content analysis used for the second, third, and fourth open-ended questions of Round 1's questionnaire.

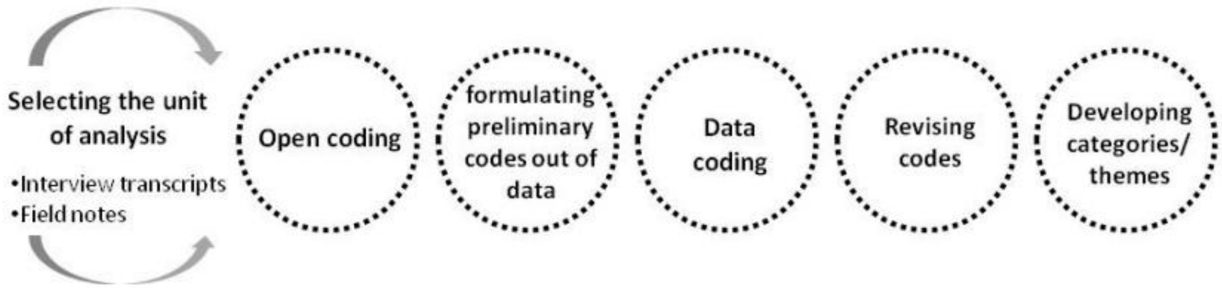


Figure 5.4 Procedure used in an inductive approach to qualitative content analysis.

(Source: Cho and Lee, 2014, p.11)

The experts' answers to the last open-ended questions were categorized based on their content for inductive or deductive quality content analysis.

5.7.4.4 Triangulation

Lastly, to increase the credibility of the qualitative content analysis, the method of triangulation was employed. Its objective was "to diminish researcher bias in the data and the likelihood of misinterpretation when checking the findings against various data sources and perspectives" (Cho and Lee, 2014, p.14). Thus, in addition to the researcher, another independent reviewer performed a separate qualitative content analysis of the experts' answers to the open-ended questions. The second independent reviewer was an experienced scholar who also met the criteria of the literature review expert sample. Overall, the triangulation process consisted of two rounds, with the suggested categories and subcategories achieving more than 90% agreement among the two reviewers upon completion of the second round (Table 5.3). Thus, the derived units and categories/subcategories were used for the development of Round 2's Delphi questionnaire.

	Categories					
	Targeted skills	*VR System*	*VR affordances*	*VR learning affordances*	*VR task category*	*ISSS*
Subcategory	1. Social 2. Communication 3. Cognitive 4. Daily living/ Functional 5. Sensorimotor 6. Behavioral & Emotional	1. Desktop 2. Semi-immersive 3. Full-immersive 4. MUVEs 5. Augmented Reality	1. Real-time interaction 2. 1st user point of view 3. Avatars 4. Presence 5. Immersion	1. Free navigation 2. Creation 3. Modeling &simulation 4. Multichannel communication 5. Collaboration & cooperation 6. Content presentation and/or delivery.	1. Social engagement 2. Interaction w/ content 3. Gaming 4. Real-life representation 5. Inquiry & experimentation	1. Cognitive 2. Motor 3. Communication 4. Computer 5. Sensory

Table 5.3 Categories and subcategories derived from a deductive approach of Round 1's qualitative content analysis.

5.7.5 *Individual and group summaries*

5.7.5.1 Individual summary

In Round 1, experts received controlled feedback in two stages. In the first stage, which followed the completion of Round 1's questionnaire administration and data analysis, the researcher prepared an individually coded summary for each participant. Each participant's answers followed the same data process and analysis (i.e., content analysis for the open-ended questions), and the summary reflected the individual's responses in Round 1. Each individualized summary was reviewed by an independent reviewer, an experienced scholar who also met the eligibility criteria for the literature review expert sample. The independent reviewer examined the organization and clarity of each individualized summary to ensure that it accurately and impartially coded the panelist's answers. Based on the reviewer's feedback, minor wording changes were made, and the updated individualized summary was reviewed once more by the independent reviewer.

Afterward, each panelist was emailed his/her individualized coded summary along with a copy of his/her original answers in Round 1. Panelists were asked to review their individualized summaries and refer to their original answers if and as needed. If panelists had any comments, questions, and/or concerns about it, they were encouraged to report them to the researcher so that necessary changes would be made. It is noteworthy that no experts reported any issues with their individualized summaries. Thus, each one of them approved it as an accurate reflection of their answers in Round 1.

5.7.5.2 Group summary

In the second stage of controlled feedback for Round 1, the researcher combined each panelist's summary into one group summary. Overall, Round-1's group summary (controlled feedback) aimed to "reduce the effect of noise [...] which occurs in a group process which both distorts the data and deals with group and/or individual interests rather than focusing on problem solving" (Hsu and Sandford, 2007, p.2). As the collected information can be biased and unrelated to the study's specific goals, a 'well-organized summary' (Hsu and Sandford, 2007) of the experts' combined and coded answers was prepared by the researcher. It was reviewed by two independent assessors, i.e., the reviewer from the first stage and one member of the pilot study who also met the eligibility criteria for the literature review expert sample.

The two independent assessors reviewed the group summary. Their goal was to ensure it was unbiased, comprehensive, and coherent. Additionally, the collected, coded, and combined information should accurately reflect the results of the study's initial rounds. The reviewers looked into the clarity of the presented information to encourage experts to problem-solve and brainstorm as they progressed to Round 2. Similar to the individual summaries, minor wording changes were proposed and incorporated. After a final check, Round 1's group was emailed to all participating experts of the study's first round. It is noted that Round 1's group summary was attached to a personalized email inviting Round-1's experts to join in Round 2, along with instructions for the completion of the new questionnaire (Appendix C).

5.8 Round 2

5.8.1 Pilot and mini pilot study (questionnaire, instructions, group summary)

5.8.1.1 Questionnaire (two drafts)

Two draft questionnaires were administered in Round 2's pilot study, and two pilot studies were conducted, one for each draft questionnaire. For both draft questionnaires, the pilot members were asked to report on similar matters as those noted in the pertinent section for Round 1, including the appropriateness of the questions for the target population, correctness, and ease of following the instructions.

The first draft questionnaire and its various versions included statements that the pilot team members were asked to rate on a 5-point Likert scale. Due to the extensive and excessive number of statements, this draft (and its pertinent versions) was rejected at the pilot study. This led to the development of a second draft that was somewhat unconventional for a second round of a Delphi study overall. Nonetheless, it spoke to the essence of the Delphi method, as it relied on, filtered, and distilled the results of the previous round. The pilot study participants were asked to "build" the VR combinations and note the skill set required for an individual with autism to benefit from that particular virtual environment. It was reported that the format of this second draft questionnaire was easy to complete and engaging. Pilot team members also noted that it allowed them to freely share their opinions and thoughts in an organized and efficient manner. Thus, the second draft questionnaire was adopted, and the pilot team's feedback was incorporated into the final draft. A mini-pilot study was conducted, and the finalized draft was then administered to the participating experts in Round 2.

5.8.1.2 Instructions

Instructions for the completion of Round 2's questionnaire were included in the online questionnaire. Nonetheless, in an effort to further facilitate experts' participation and the efficient and accurate completion of Round 2's questionnaire, additional information was provided. More specifically, pertinent information was attached to the personalized email sent to invite the participating experts from Round 1 to the study's Round 2. The process for these instructions was similar to the steps and purpose described for the draft questionnaire. Thus, the two independent reviewers also provided feedback on Round 2's questionnaire instructions, which were incorporated and then mini-pilot-tested. After completing these steps, the pertinent document, accompanied by Round 2's questionnaire, was shared with the experts (Appendix C).

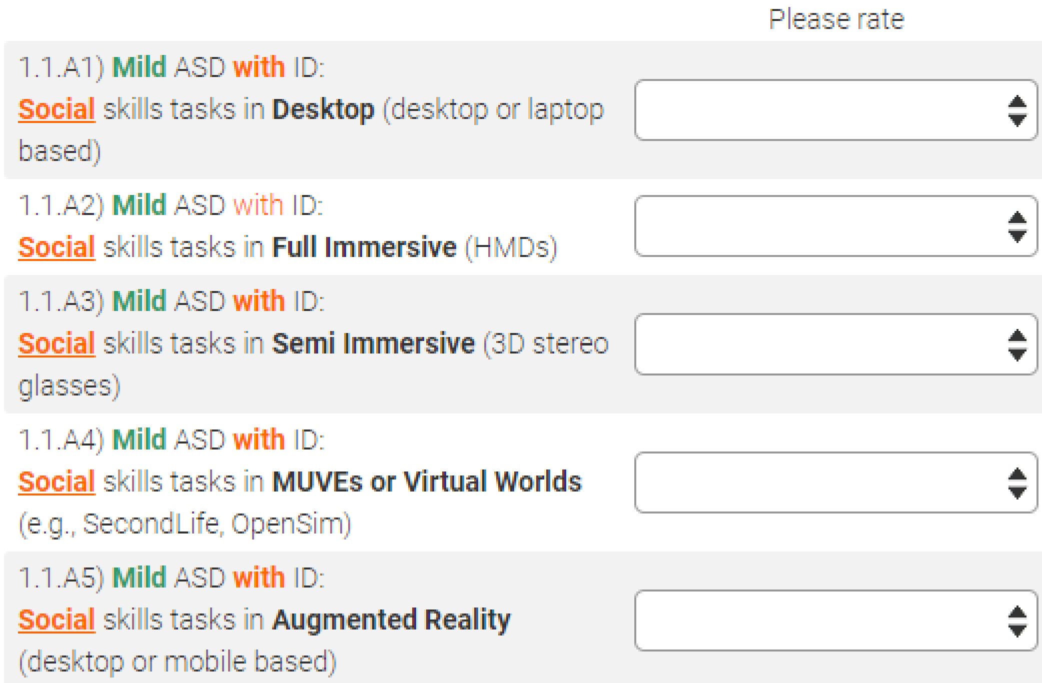
5.8.1.3 Group summary

Round 2's group summary followed similar steps to the ones described for the group summary of Round 1. The summary was attached to the personalized email sent to the participating experts of Round 2, inviting them to contribute to the study's final and third rounds. This process is described in more detail in the section 'Group summary' at the end of Round 2.

5.8.2 *Questionnaire*

5.8.2.1 First draft questionnaire (abandoned)

The first draft questionnaire for Round 2 resembled the format often found in the second round of a Delphi study. Thus, it contained statements for the experts to rate on a 5-point Likert scale. The statements were derived from the qualitative data of Round 1. They presented all the possible combinations of VR systems, VR affordances, VR learning affordances, VR tasks, and skill set(s) an individual with autism should have to benefit from the suggested virtual environment. Several versions of this draft (at least three) were attempted, either more condensed or more descriptive, in an effort to exhaust all possible combinations in an unbiased and efficient manner. All versions, although straightforward and easy to complete, resulted in an extensive number of statements, leading the pilot team members to report that they were very time-consuming and laborious to complete. Based on the pilot team's feedback, as well as pertinent literature that suggests experts are less likely to participate in lengthy questionnaires with numerous statements (Keeney, McKenna and Hasson, 2011), this draft and its relevant versions were ultimately abandoned (Figure 5.5).



Please rate

1.1.A1) **Mild** ASD **with** ID:
Social skills tasks in **Desktop** (desktop or laptop based)

1.1.A2) **Mild** ASD with ID:
Social skills tasks in **Full Immersive** (HMDs)

1.1.A3) **Mild** ASD **with** ID:
Social skills tasks in **Semi Immersive** (3D stereo glasses)

1.1.A4) **Mild** ASD **with** ID:
Social skills tasks in **MUVEs or Virtual Worlds** (e.g., SecondLife, OpenSim)

1.1.A5) **Mild** ASD **with** ID:
Social skills tasks in **Augmented Reality** (desktop or mobile based)

Figure 5.5 One of the numerous versions of the statement draft questionnaire for Round 2.

5.8.2.2 Second draft questionnaire (adopted)

The second draft of Round 2's questionnaire (Appendix C) had five sections, with the last section having four subsections. The first section included an introductory and welcoming message to the experts. The second section provided an overview of the questionnaire, along with additional information (e.g., the study's content and consent, the researcher's contact details). The third section had color-coded information about the questionnaire's structure. The fourth section provided a comprehensive list of the pre-selected answers that experts could choose to fill in this questionnaire, along with relevant abbreviations.

Regarding the fifth section, it was designed and structured to be efficient, flexible, ergonomic, and unbiased. This way, experts could freely share their opinions while being exposed to the views of other panelists. Moreover, in this section, experts were introduced and presented with the following four clinical profiles of individuals with ASD: i) mild ASD with ID (Profile 1), ii) mild ASD without ID (Profile 2), iii) severe ASD with ID (Profile 3), and iv) severe ASD without ID (Profile 4). The four clinical profiles aimed to provide additional clarity to the experts' answers and, therefore, to the suggested framework of design guidelines. The suggested clinical profiles were based on the DSM-5's (2013) severity and comorbidity criteria, as well as the experts' answers in Round 1.

Under each clinical profile, experts were expected to consider designing tasks in VR for individuals with ASD to work on the following six targeted skill areas: 1. social skills, 2. communication skills, 3. cognitive skills, 4. daily living/functional life skills, 5. sensorimotor skills, and 6. behavioral and emotional skills. Next, and while keeping in mind each of the four different ASD profiles (Profiles 1-4) as well as the six targeted skills areas, experts selected the VR combination (comprised from a VR system, a VR affordance, a VR learning affordance, and a VR task/activity category) that in their opinion would be the most appropriate for each case. Experts were also asked to select the Individuals' Specific Skills Set (ISSS), i.e., a specific set of skills that individuals with each ASD profile should adequately demonstrate to benefit from the proposed VR combinations. It is noted that ISSSs are differentiated from the six targeted skill areas. Figure 5.6 offers a schematic representation of Round 2.

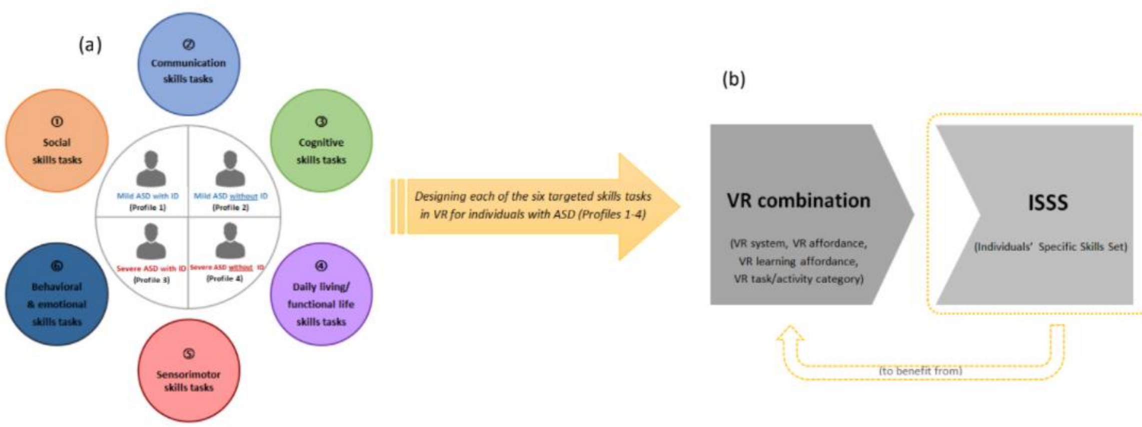


Figure 5.6 Six targeted skill areas for the respective design of tasks in VR, suitable for individuals with ASD Profiles 1-4 (a). Selection of the appropriate VR combination and ISSS for individuals with ASD to receive benefits from the VR combination (b).

In essence, and for this last section, the experts' answers from Round 1's open-ended questions were converted into statements. Based on the results of the pilot study for the first draft questionnaire, the researcher was able to convert Round 1's open-ended questions into categorized statements. This was expected to help reduce the time required to complete the questionnaire and process the data. At the same time, the experts' response rate was anticipated to possibly increase (Keeney, McKenna and Hasson, 2011). With regard to the VR combinations and in an effort to condense a significant number and variety of categorical data, the experts were asked to "build" their response from a series of pre-selected options (that also included the "N/A" and "Other" options, with a description box for the latter) provided through drop-down menus (Figure 5.7). For the selection of ISSSs, the experts were provided a checklist (which also included the "N/A" and "Other" options, along with a description box for the latter) to select from for their answer (Figure 5.8).

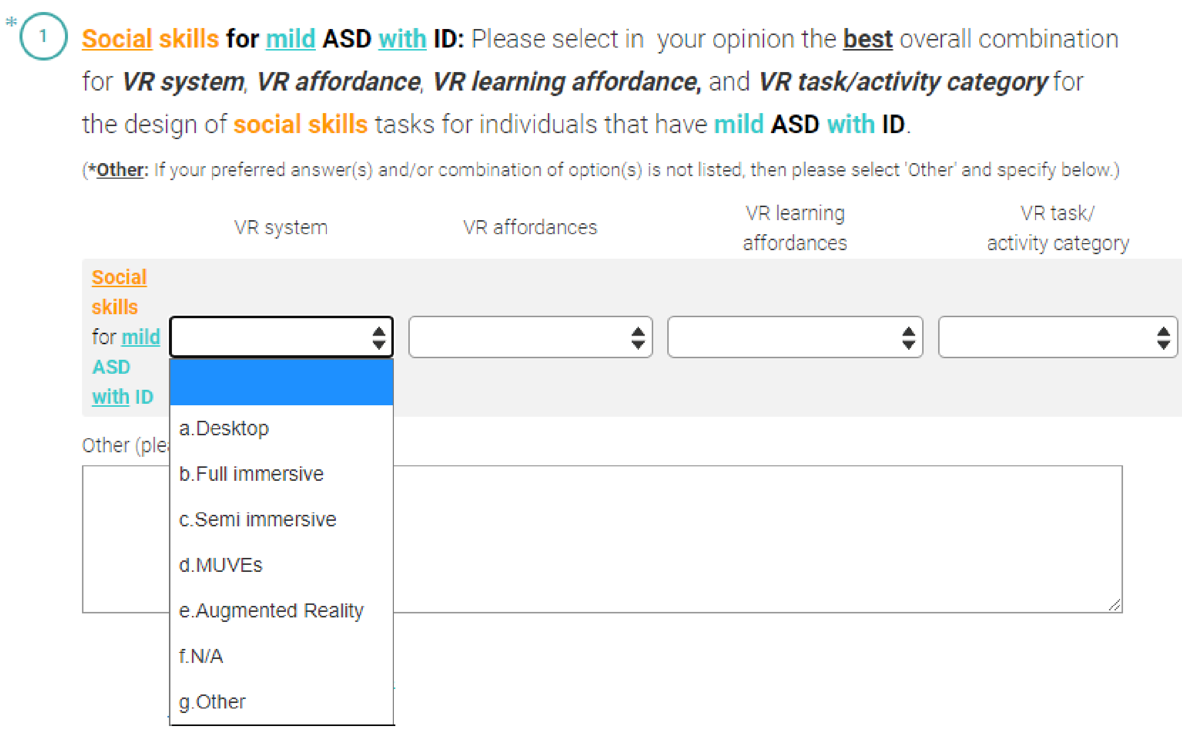


Figure 5.7 Screenshot of Round 2's questionnaire, drop-down menu for building a VR combination.

* 2 Social skills for mild ASD with ID and individuals' set of skills/characteristics: Keeping in mind your **answer in the previous** question (**Q1**), please select in your opinion the specific **set of skills/characteristics** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to access and benefit from the combination of VR system, VR affordance and VR learning affordance you previously selected when targeting **social** skills tasks in VR.

(***Other**: If your preferred answer(s) is not listed and/or wish to provide additional information, then please select 'Other' and specify below.)

- a. Cognitive skills
- b. Executive skills
- c. Communication skills
- d. Motor skills
- e. Sensory skills
- f. Computer interest/skills
- g. Attention
- h. Academic skills
- i. Imagination/curiosity/motivation
- g. Independent use of VR system
- k. All of the above
- l. N/A
- Other (please specify)

Figure 5.8 Screenshot of Round 2's questionnaire, checklist for the ISSS selection.

5.8.3 Administration

Similarly, to Round 1, an invitation email was sent via the SurveyMonkey® platform mailing list to the 22 participating experts from Round 1 of the study. It included a link that automatically redirected them to Round 2's online questionnaire. The SurveyMonkey® email was followed by a personalized email to each expert inviting them to Round 2. The email also included Round 1's group summary and instructions for the completion of Round 2's online questionnaire. The panel was given ten days to complete Round 2's questionnaire. The deadline was extended twice, by ten days each time. Similarly, to Round 1, approximately three days before the cut-off date, a reminder was sent via the SurveyMonkey® platform to each expert who had not completed the questionnaire. After the cut-off date, a personalized email was sent to the experts who had not submitted the questionnaire by the initial deadline, offering assistance and a ten-day extension for its completion. Following the submission of a completed questionnaire, the participating experts received a personalized thank-you email for their contribution. This process, i.e., emails (personalized and via SurveyMonkey®) for reminders, follow-ups, and thanking experts for their participation, was repeated for the second extension of the deadline. A total of 13 experts completed Round 2's questionnaire. Following the collection and process of the experts' answers, a group summary of Round 2's results was prepared. The group summary was provided in the personalized email inviting the 13 experts participating in Round 2 of the study to the study's final and third Round.

5.8.4 Data collection and analysis

The experts' answers in Round 2 were automatically collected and stored in the SurveyMonkey® platform upon submission of the questionnaire. The panel's responses were qualitative; thus, descriptive statistics, specifically modes, were used for the categorical data with the highest frequency. Thus, the proposed VR combinations and the Individuals' Specific Set of Skills (ISSS) from Round 2 were processed in reference to the four ASD profiles and each of the six targeted skills. The results with the highest number of occurrences (mode) for each value (VR system, VR affordances, VR learning affordances, VR task/activity category, and Individuals' Specific Skill Set) were selected and presented in Round 3 (Figure 5.9).

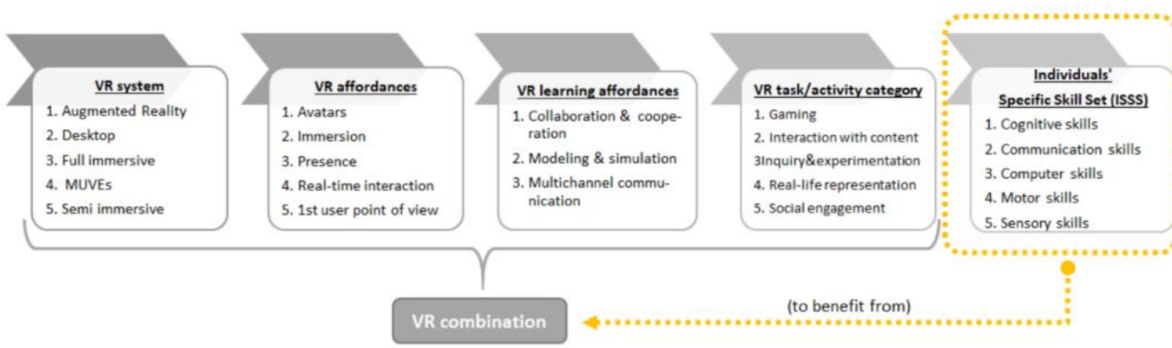


Figure 5.9 Results with the highest frequency (mode) from Round 2. Listed in alphabetical order and for each of the five values (VR system, VR affordances, VR learning affordances, VR task/activity category, and ISSS).

5.8.5 Group summary

A group summary of Round 2's results was prepared and reviewed by two independent scholars. The purpose of this double independent review was similar to what has been described in Round 1's group summary, i.e., ensuring that the provided information was unbiased, comprehensive, and coherent, among other things. One of the two independent reviewers was the same scholar who participated in this process during Round 1. The second reviewer was a scholar with extensive experience in research methodology and Delphi studies. Their feedback was incorporated, and the updated group summary was then mini-pilot tested. Afterwards, the final draft for Round 2's summary (Appendix C) was provided to the experts (along with the instructions to Round 3's questionnaire) via a personalized email inviting them to participate in the study's last and third round.

5.9 Round 3

5.9.1 Pilot and mini-pilot study

5.9.1.1 Questionnaire

Similarly, for Round 2, a draft questionnaire was prepared and pilot-tested. Initially, the pilot team's feedback was incorporated, and then the updated questionnaire was mini-pilot tested. The final draft of Round 3's questionnaire was then administered to the participating experts.

5.9.1.2 Instructions

Similarly, for Round 2, an instructions draft was prepared, reviewed by two independent scholars, and then mini-pilot tested. The reviewers' and mini-pilot team's feedback was incorporated, and the final draft was shared in a personalized email inviting Round 2's participating experts to contribute to the study's final and third rounds.

5.9.2 Questionnaire

Round 3’s questionnaire (Appendix C) consisted of three sections. The first section included basic information, such as the study's content and consent, acknowledgment of consent, and contact details. The second section included thorough and color-coded information (key points) regarding the questionnaire’s content, format, organizational structure, and rationale. Abbreviations and terms were also explained at the end of the second section. The third and last section had four subsections corresponding to each of the four suggested autism profiles (i.e., Profile-1: mild ASD with ID; Profile-2: mild ASD without ID; Profile-3: severe ASD with ID; Profile-4: severe ASD without ID).

Each clinical profile had a series of verbatim benchmark statements (Figures 5.10-5.11) that experts were asked to rate on a 5-point Likert scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree). These statements were derived from experts’ responses (i.e., qualitative data) in Round 2. More specifically, the VR combinations (i.e., VR system, VR affordances, VR learning affordances, and VR tasks) and corresponding skill set(s) (ISSS) that received the most frequent scores (i.e., modes) in Round 2 advanced to Round 3. The formed statements corresponded to each of the four suggested autism profiles (Profiles 1-4) and were rated on a 5-point Likert scale. With the use of descriptive statistics, statements that achieved a consensus of 75% or greater were included in the framework of suggested design guidelines.

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q1 Designing social skills tasks **for mild ASD with ID** Please rate the following **VR combination:** - Semi immersive (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q1.1 Designing social skills tasks with Q1's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills:** - Cognitive skills	○	○	○	○	○
Q1.2 Designing social skills tasks with Q1's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills:** - Motor skills	○	○	○	○	○

Figure 5.10 Round 3's questionnaire, statements from Profile-1 to be rated.

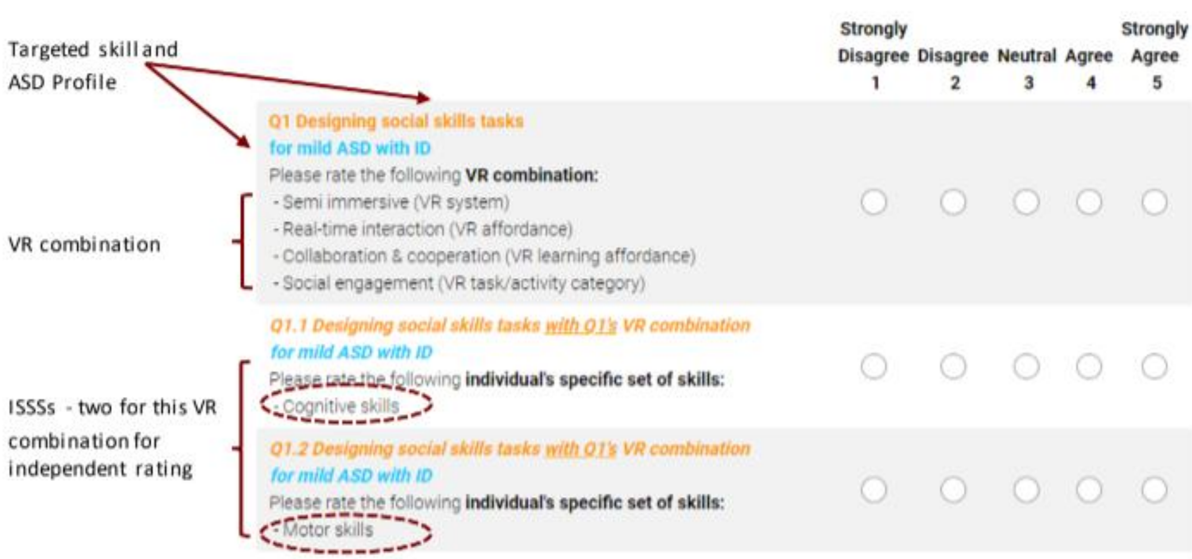


Figure 5.11 From Round 3's instructions: "Snapshot from Round 3's Questionnaire; rating statements and 5-point Likert scale (agree/disagree). In this example, the rating statements concern individuals who have mild ASD with ID. The tasks designed in VR target individuals' social skills. The VR combination is provided and rated first, followed by the ISSSs. In this case, two ISSSs are corresponding to this particular VR combination - ISSSs are noted to be rated independently at all times."

5.9.3 Administration

Similarly to the previous rounds, an email was sent via the SurveyMonkey® platform to the 13 participating experts of Round 2 of the study. It included a link that automatically redirected them to Round-3's online questionnaire (Figure 5.12). The SurveyMonkey® email was soon followed by a personalized email to each expert inviting them to Round 3 of the study. The group summary from Round 2 and instructions for the completion of Round 3's online questionnaire were also included. The panel was given ten days to complete Round 3's questionnaire. The deadline was extended twice, by ten days each time. Emails (personalized and via SurveyMonkey®) were sent for reminders, follow-ups, and to thank experts for their participation, following a similar process to that described for the previous two rounds.

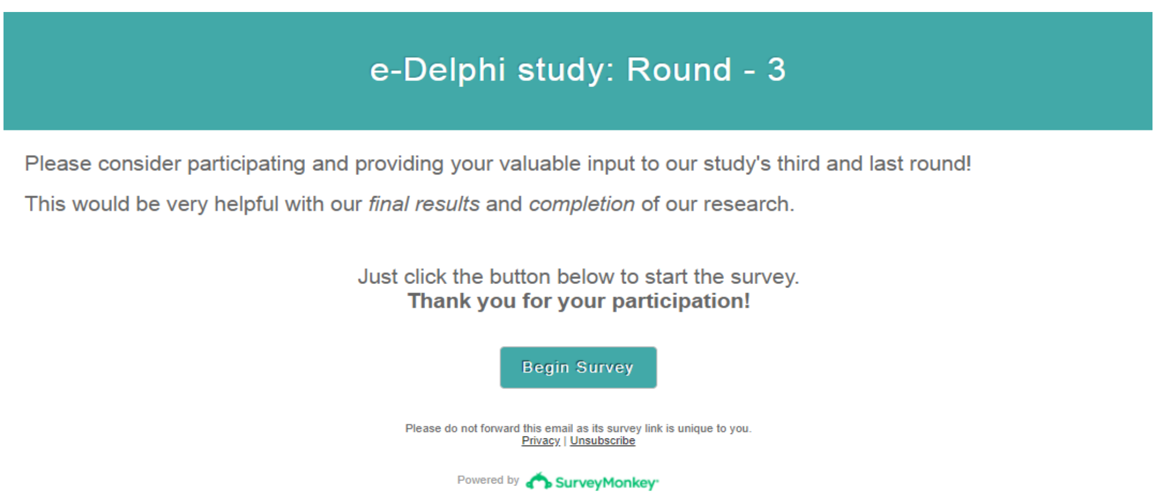


Figure 5.12 Email invitation to the study's Round 3 online questionnaire via the SurveyMonkey® mailing system.

5.9.4 Data collection and analysis

Upon the completion and submission of Round 3's online questionnaire, participants' answers were automatically collected and stored on the SurveyMonkey® platform. Statements that reached a consensus level of at least 75% were part of the proposed design guidelines for virtual environments for individuals with autism.

5.10 Ethical considerations

Experts were informed they could opt out at any stage of the study without detriment. They were also informed about actions taken to protect their confidentiality, identity, privacy, data, and answers during and after completion of the study. The aforementioned were described in detail at the beginning of the study's Round 1 ('Invitation and information about the e-Delphi study'). It is noted that, although it was not possible to maintain total anonymity during the study, as the researcher knew the origin of individual responses, quasi-anonymity, as described by McKenna (1994), was nonetheless ensured. In our study, any possible identifying information (e.g., specific job titles and areas of work) was omitted from any reports or presentations emanating from the study. Although participants' identities and their responses were not anonymous to the researcher, they were anonymous to each other. Lastly, the study abided by the ethical requirements of the "Research Ethics Committee" of the University of Ioannina, Greece.

Chapter 6

RESULTS

6.1 Introduction

This chapter presents the results of the study, analyzed for each of the three rounds administered during the Delphi study. Due to a large amount of collected categorical data and their significant spread, content analysis was used for Round 1's results, and descriptive statistics were used for Round 2 and 3's results.

6.1.1 Descriptive statistics

Laerd Statistics (https://statistics.laerd.com/) states the following regarding descriptive statistics: "Descriptive statistics is the term given to the analysis of data that helps describe, show, or summarize data in a meaningful way such that, for example, patterns might emerge from the data. Descriptive statistics do not, however, allow us to make conclusions beyond the data we have analyzed or reach conclusions regarding any hypotheses we might have made. They are simply a way to describe our data. Descriptive statistics are vital because if we simply presented our raw data, it would be difficult to visualize what the data is showing, especially if there is a lot of it. Descriptive statistics, therefore, enable us to present the data in a more meaningful way, which allows a simpler interpretation of the data. [...] We would also be interested in the distribution or spread of the marks. Descriptive statistics allow us to do this. [...]" (https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php).

6.1.2 Measures of central tendency and measures of spread

There are two general types of statistics used to describe data: measures of central tendency and measures of spread. Regarding the measures of central tendency, "these are ways of describing the central position of a frequency distribution for a group of data. [...] We can describe this central position using a number of statistics, including the mode, median, and mean" (https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php). As far as the measures of spread are concerned, "these are ways of summarizing a group of data by describing how to spread out the scores are. [...] Measures of spread help us to summarize how spread out these scores are. To describe this spread, a number of statistics are available to us, including the range, quartiles, absolute deviation, variance and standard deviation" (https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php). In our study, we will use the mode to describe the categorical data collected in Rounds 2 and 3.

6.1.3 Mode

The mode is used for categorical data when wanting to know the most common category, i.e., the most frequent score (popular option) in a data set (https://statistics.laerd.com/statistical-guides/measures-central-tendency-mean-mode-median.php).

6.2 Results of Round 1

A total of 91 potential and international expert panel members (N_0=91) were identified through an extensive review of the literature (N_{LR0}=74, 81.31%) and snowball sampling (N_{Sn0}=17, 18.68%) (Figure 6.1). The identified experts presented a diverse range of backgrounds, including computer science/engineering, educational technology, physics/math, medicine, psychology, education/pedagogy, special education, and language arts, linguistics, and literature. The potential experts held positions mainly in the following five professional groups: academia, research, computer programming, psychology, and medicine. Overall, the employment levels/grades of individual members varied within each group, bringing various perspectives to the study (e.g., practice, education, and research).

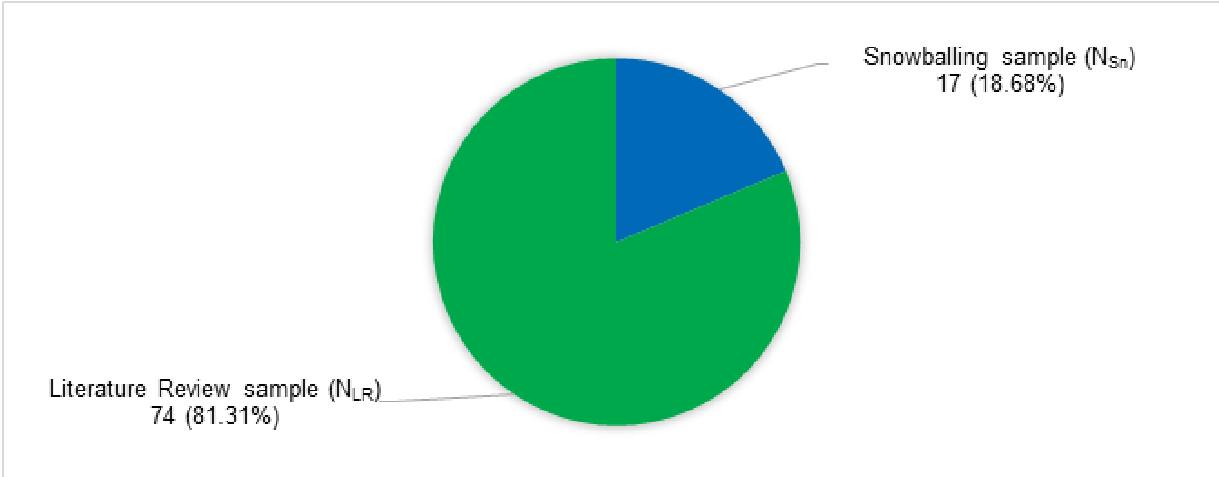


Figure 6.1 Identified potential experts (N_0=91)

Regarding the initial literature review sample, out of the 74 potential experts (N_{LR0}=74), in six cases, there was a failure to deliver emails to their accounts. In five cases, a valid and working email address could not be found despite several efforts. Thus, the total number of identified and potential participating experts from the literature review was 63 (N_{LR}=63). Regarding the initial snowballing sample, out of the 17 recommended potential experts (N_{Sn0}=17), three individuals didn't meet our eligibility criteria. Thus, their participation in this study was not warranted, bringing the total number of identified and potential participating experts from snowballing to 14 (N_{Sn}=14) (Figure 6.2).

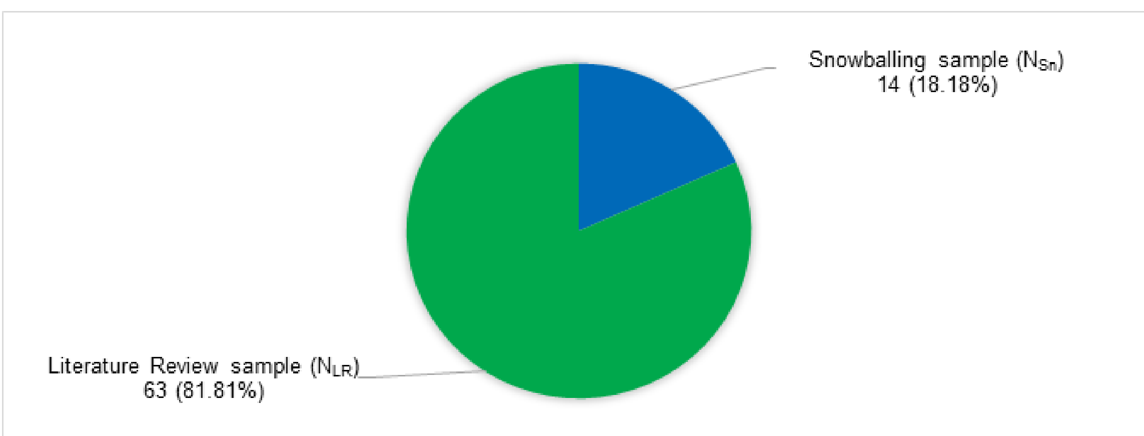


Figure 6.2 Potential participating experts (N=77)

Moving to the study's Round 1, 22 out of the 77 identified potential participants were eligible to participate, and experts completed the first round (i.e., a 28.57% response rate). Regarding the sampling of Round-1's participating experts, 15 experts originated from the literature review (N_{LR-R1}=15, 68.18%), and seven experts originated from the snowballing sampling (N_{Sn-R1}=7, 31.81%). The charts below depict the overall sampling of the study's participants, as well as their distribution per each of the three rounds (Figure 6.3).

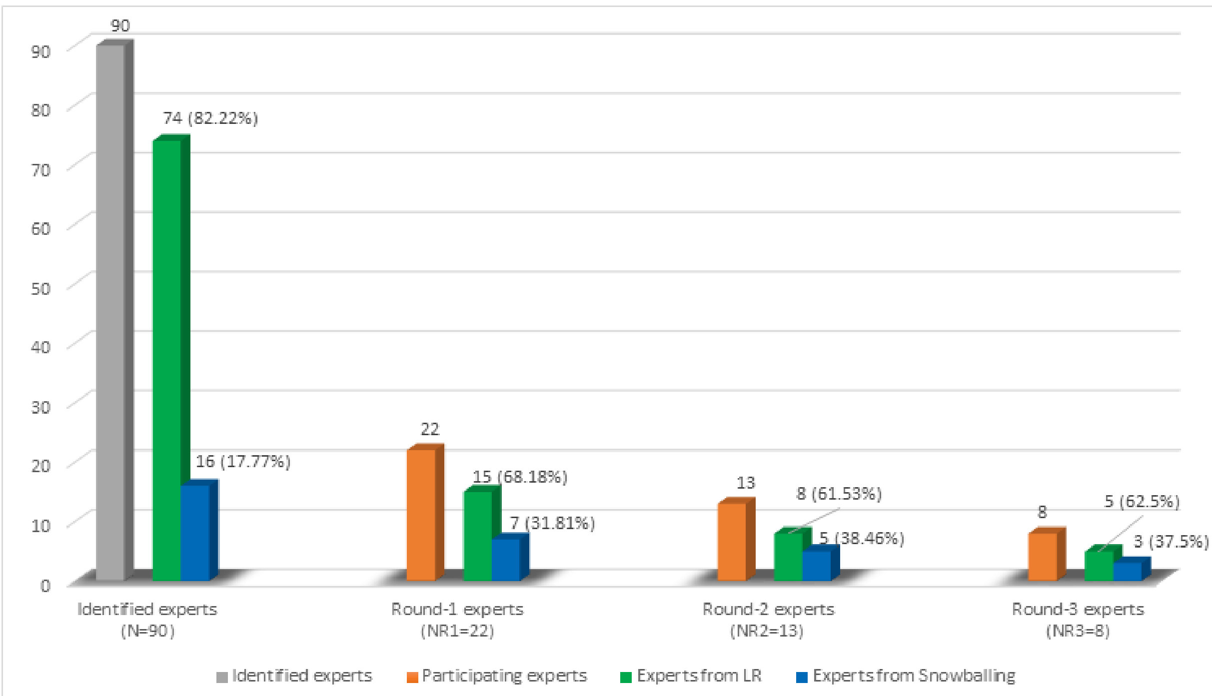


Figure *6.3* Samples of the study's identified and participating experts

6.2.1 Demographic data

Pertinent demographic data were collected through the five brief closed-ended questions previously presented in Chapter 5 (Methodology). Experts' answers revealed a diverse international panel from 10 different countries and three continents (Europe, North America, and Asia) (Figure 6.4). Also, and regarding the panel's educational background, half of the panel, 11 experts, had an educational background in Computer Science/Engineering (50%), followed by four experts with a background in Educational Technology (18.18%), two experts with a background in Psychology (9.09%), and five experts had a variety of educational backgrounds such as (22.73%) (Figure 6.5).

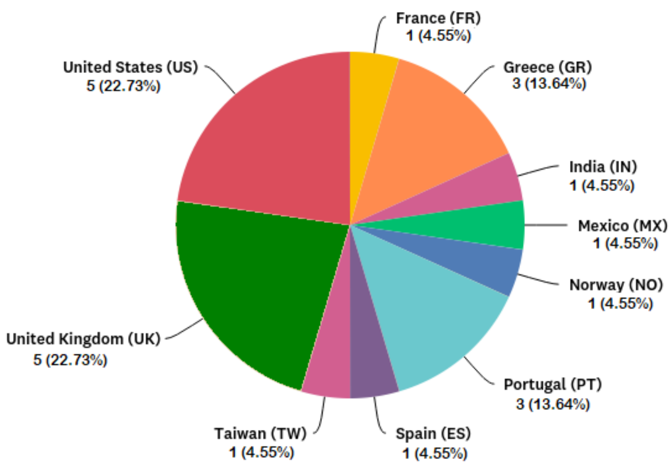


Figure 6.4 Experts' country of professional origin (Q4[9], N=22)

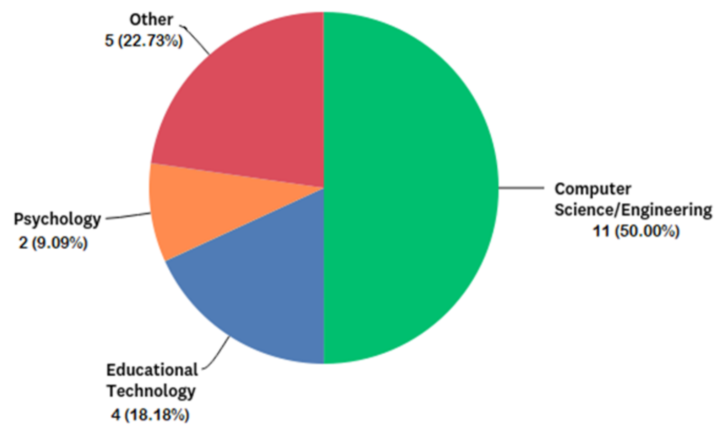


Figure 6.5 Experts' educational background (Q1[10], N=22)

Regarding the experts' current professional position and working setting, the majority, 17 experts, worked as faculty in a University (77.22%), one worked as a researcher in an Institute (4.55%), and four experts were in other/a variety of positions (Figure 6.6) and working settings (Figure 6.7).

[9]Q4: "In which country is your current professional position located? (Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)"

[10] Q1: "What is your educational background? (Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)"

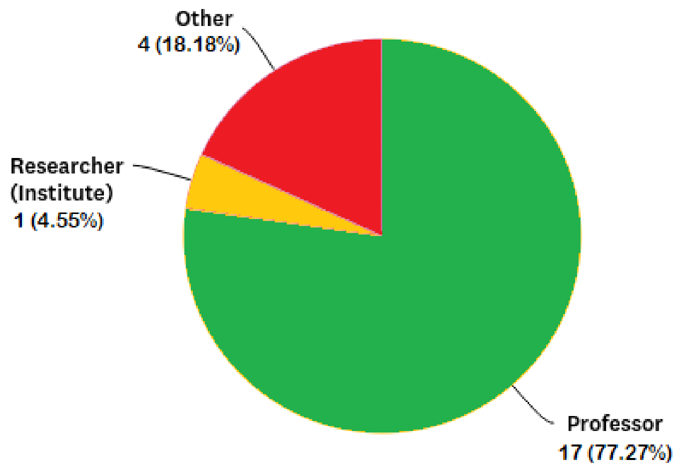


Figure 6.6 Experts' professional position (Q2[11], N=22)

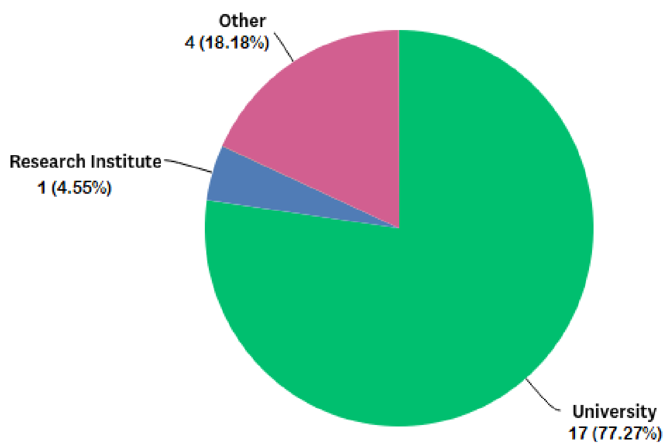


Figure 6.7 Experts' work setting (Q3[12], N=22)

[11] Q2: "What is your current professional position? (Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)"

[12] Q3: "Where is your current professional position? (Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)"

Regarding the experts' experience in VR and ASD separately and combined, their answers are depicted in Figure 6.8.

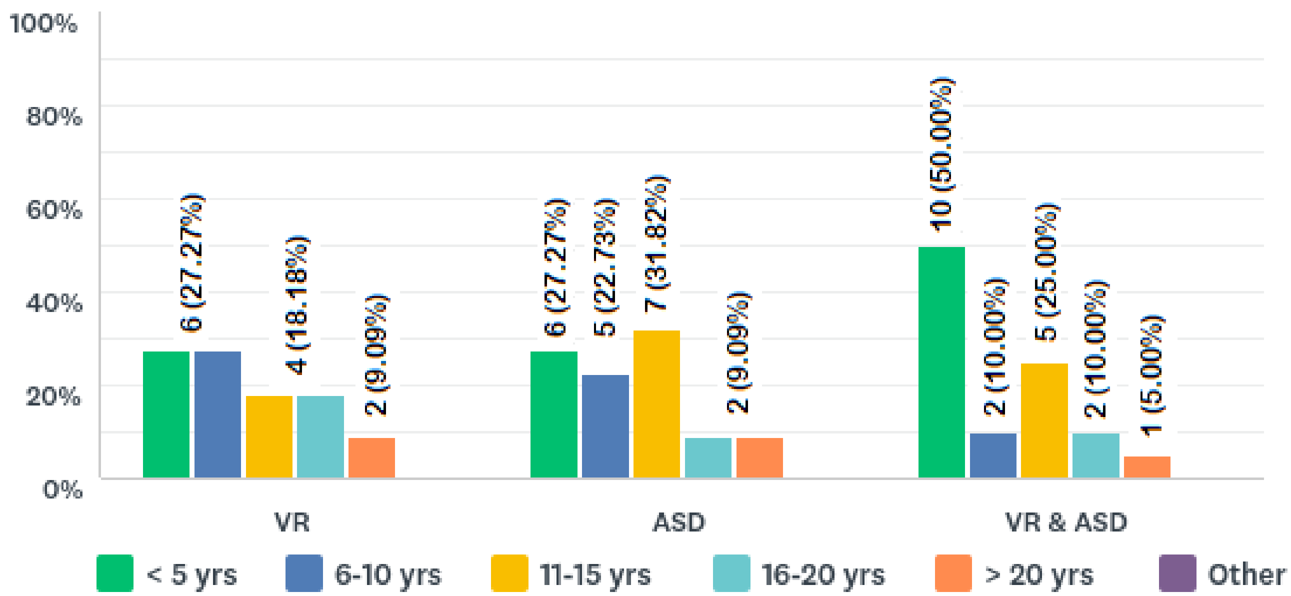


Figure 6.8 Experts' experience with VR, ASD, and VR & ASD (Q5[13], N=22)

6.2.2 Open-ended questions

The content analysis of this round's open-ended questions revealed six categories, each with five to six subcategories. The relevant results are depicted in Table 6.1.

[13] Q5: "How many years of experience do you have with VR, ASD, and VR & ASD? (Please select the best answer for each of the three columns.)"

Table 6.1 Categories and subcategories derived from a deductive approach of Round 1's qualitative content analysis.

Category	*Targeted skills*	*VR System*	*VR affordances*	*VR learning affordances*	*VR task category*	*ISSS*
Subcategory	1. Social 2. Communication 3. Cognitive 4. Daily living/ Functional 5. Sensorimotor 6. Behavioral & Emotional	1. Desktop 2. Semi-immersive 3. Full-immersive 4. MUVEs 5. Augmented Reality	1. Real-time interaction 2. 1st user point of view 3. Avatars 4. Presence 5. Immersion	1. Free navigation 2. Creation 3. Modeling and simulation 4. Multichannel communication 5. Collaboration and cooperation 6. Content presentation and/or delivery.	1. Social engagement 2. Interaction w/ content 3. Gaming 4. Real-life representation 5. Inquiry & experimentation	1. Cognitive skills 2. Motor skills 3. Communication skills 4. Computer skills 5. Sensory skills

6.3 Results of Round 2

As mentioned earlier, for the statistical analysis of Round 2's results, various parametric and non-parametric statistical models (found in Delphi studies and overall) were explored. However, due to the large number of categorical data collected and their significant spread, descriptive statistics and measures of central tendency (mode) were used. The mode used for categorical data, when seeking to identify the most common category, i.e., the most frequent score/popular option in a dataset, is illustrated in the data presented in the tables below. Additionally, in cases where the mode was not unique for a data set, i.e., when two or more values share the highest frequency, both values were selected for our study.

Tables 6.2, 6.3, 6.4, and 6.5 show the results of the study's Round 2. Each table corresponds to one of the four selected clinical profiles for individuals with ASD, i.e., mild ASD with ID (Profile-1); mild ASD without ID (Profile-2); severe ASD with ID (Profile-3), and severe ASD without ID (Profile-4). 13 experts (N_{R2}=13) participated in Round-2, bringing the response rate for the study's Round 2 to 59.09% (i.e., 13 experts participated in Round 2 out of the 22 experts who participated in Round 1). It is noted that one out of the 13 participating experts partially completed this round's questionnaire (only Profile-1, as the expert felt more comfortable due to their research with the questions about individuals with the clinical Profile-1 (as per email communication between the expert and the researcher). Regarding the demographic characteristics (i.e., country, educational background, professional position, working setting, and experience) of the experts in this Round 2, they are presented below to provide further perspective on this round's results (Figures 6.9-6.13).

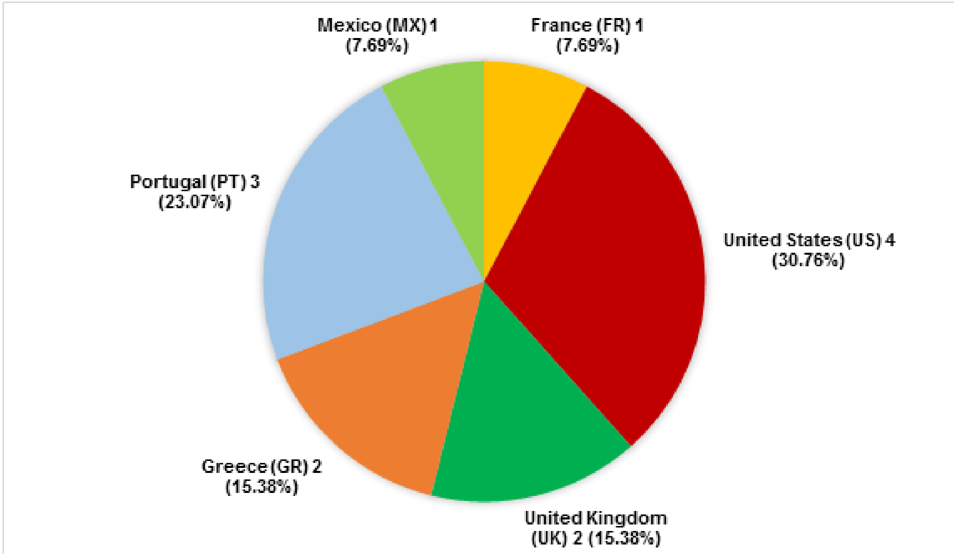


Figure 6.9 Round 2, experts' country of professional origin (N_{R2}=13)

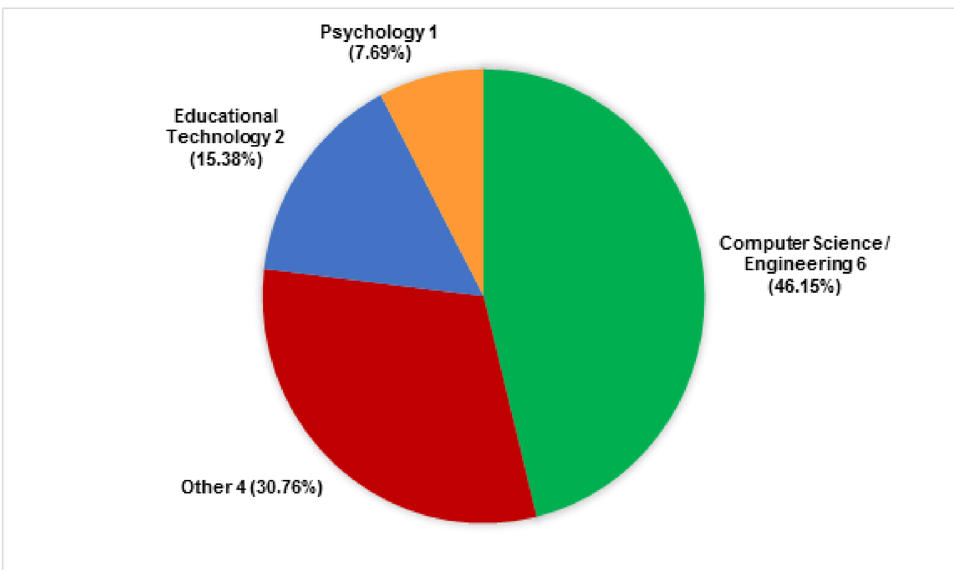


Figure 6.10 Round 2, experts' educational background (N_{R2}=13)

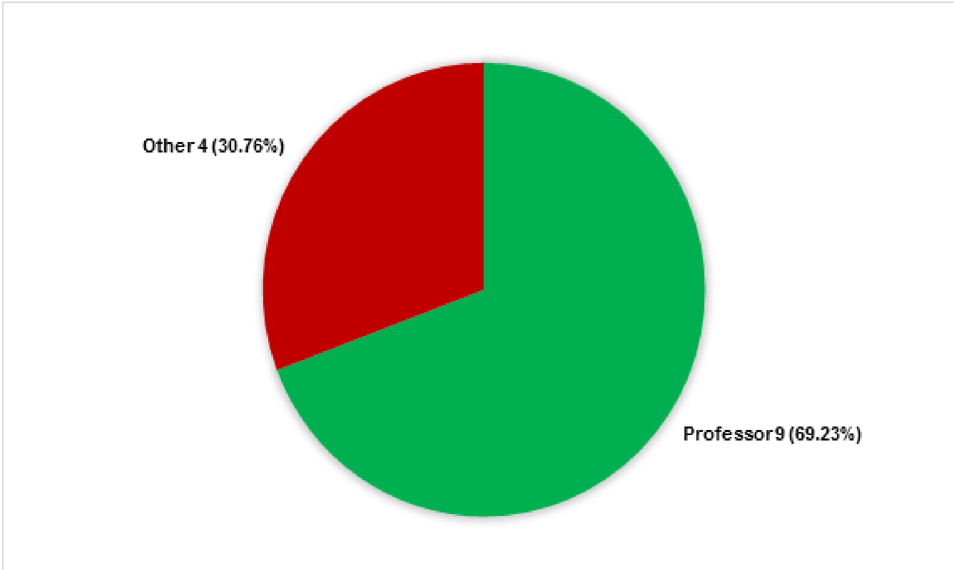


Figure 6.11 Round 2, experts' professional position (N_{R2}=13)

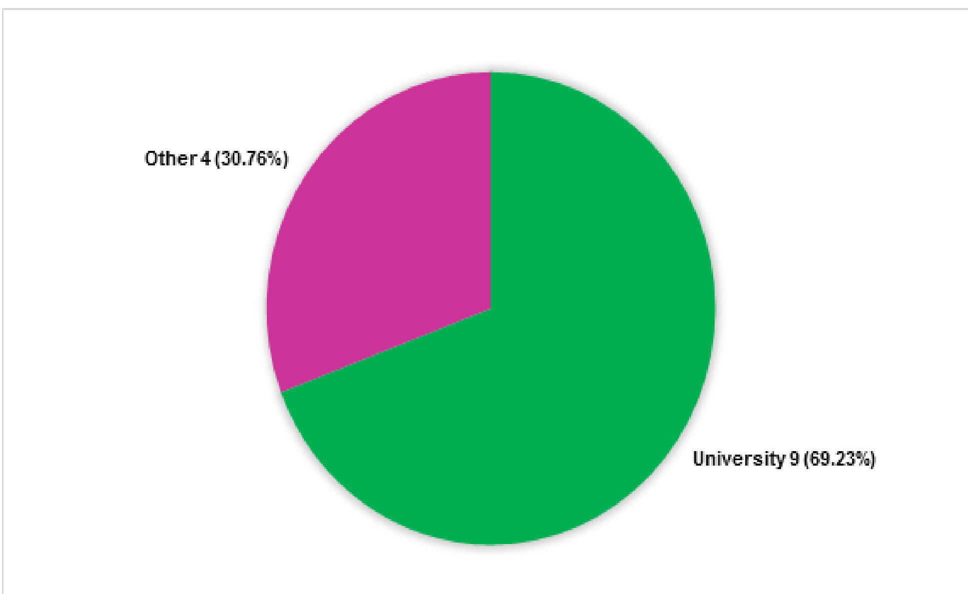


Figure 6.12 Round 3, experts' work setting (N_{R2}=13)

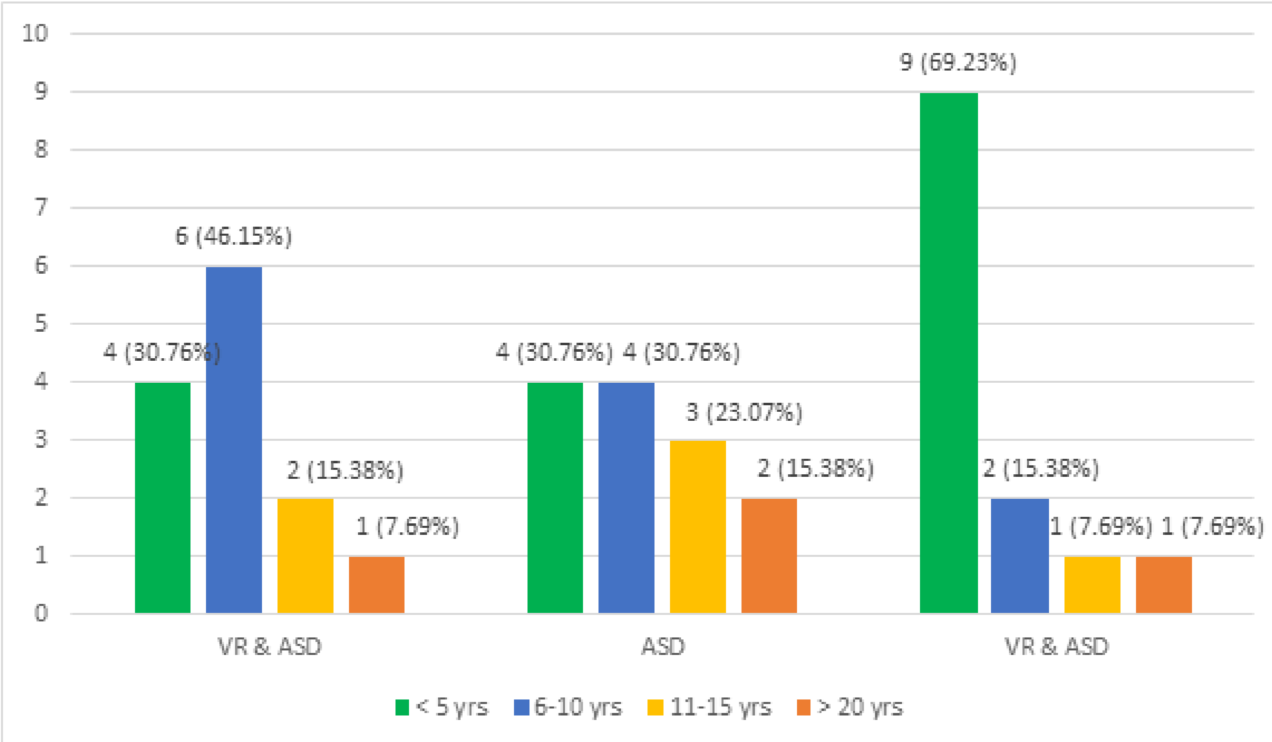


Figure 6.13 Round 2, experts' experience with VR, ASD, and VR & ASD (N_{R2}=13)

A total of 48 questions were administered, and the pertinent answers were color-coded according to the targeted skills (as in the online questionnaire). Experts' answers were also organized based on the categories and subcategories derived from the deductive approach of Round 1's qualitative content analysis.

There were 12 questions for each of the four clinical profiles, with two questions for each of the six targeted skills. One question pertained to the VR combination (i.e., VR system, VR affordances, VR learning affordances, and VR task category) that experts believed would benefit individuals with that specific clinical profile the most. The second question pertained to the skills individuals should have to benefit from the suggested VR combinations.

6.3.1 Results of Round 2: Profile-1, Mild ASD with ID

All 13 participants in the study's Round 2 completed the 12 questions (Q1-Q12) regarding individuals with mild ASD and ID (Profile 1). The modes from the data collected are shown in Table 6.2.

Table 6.2 Modes of the data collected from Round 2 for individuals with Mild ASD and ID (Profile -1)

Profile – 1:
Mild ASD with ID

Tasks	VR Combination				N_a=13 experts
	VR system	**VR affordances**	**VR learning affordances**	**VR task category**	**ISSS**
Social skills (Q1 & Q2)	Semi-immersive (38.46% or 5/13)	Real-time interaction (30.77% or 4/13) 1st user point of view (30.77% or 4/13)	Collaboration & cooperation (46.15% or 6/13)	Social engagement (61.54% or 8/13)	Cognitive skills (69.23% or 9/13) Motor skills (46.15% or 6/13)
Communication skills (Q3 & Q4)	Full-immersive (23.08% or 3/13) MUVEs (23.08% or 3/13) Augmented Reality (23.08% or 3/13)	Avatars (23.08% or 3/13) Real-time interaction (23.08% or 3/13) 1st user point of view (23.08% or 3/13)	Collaboration & cooperation (38.46% or 5/13)	Social engagement (53.85% or 7/13)	Communication skills (84.62% or 11/13)
Cognitive skills (Q5 & Q6)	Desktop (38.46% or 5/13)	Real-time interaction (46.15% or 6/13)	Modelling & simulation (46.15% or 6/13)	Inquiry & experimentation (38.46% or 5/13) Interaction w/content (38.46% or 5/13)	Computer skills (69.23% or 9/13)

Modes

	Daily living/ Functional skills (Q7 & Q8)	Augmented Reality (46.15% or 6/13 👫)	Real-time interaction (46.15% or 6/13 👫)	Modeling & simulation (38.46% or 5/13 👫)	Real-life representation (53.85% or 7/13 👫)	Motor skills (84.62% or 11/13 👫)	
	Sensorimotor skills (Q9 & Q10)	Full-immersive (30.77% or 4/13 👫) Semi-immersive (30.77% or 4/13 👫)	Real-time interaction (30.77% or 4/13 👫)	Modelling & simulation (53.85% or 7/13 👫)	Interaction w/content (38.46% or 5/13 👫)	Motor skills (76.92% or 10/13 👫)	
	Behavioral & Emotional skills (Q11 & Q12)	Full-immersive (30.77% or 4/13 👫)	Presence (30.77% or 4/13 👫)	Modeling & simulation (38.46% or 5/13 👫)	Social engagement (46.15% or 6/13 👫)	Communication skills (76.92% or 10/13 👫)	

6.3.2 Results of Round 2: Profile -2, Mild ASD without ID

Twelve out of the 13 participants of the study's Round 2 completed the 12 questions (Q13-Q24) regarding individuals with mild ASD and without ID (Profile-2). The modes from the data collected are shown in Table 6.3.

Table 6.3 Modes of the data collected from Round 2 for individuals with mild ASD and without ID (Profile - 2)

Profile – 2:
Mild ASD without ID

Tasks		VR Combination				N_b=12 experts	Modes
		VR system	**VR affordances**	**VR learning affordances**	**VR task category**	**ISSS**	
	Social skills (Q13 & Q14)	MUVEs (41.67% or 5/12)	Real-time interaction (25.00% or 3/12) Presence (25.00% or 3/12)	Collaboration & cooperation (41.67% or 5/12)	Social engagement (66.67% or 8/12)	Communication skills (83.33% or 10/12)	
	Communication skills (Q15 & Q16)	Full immersive (33.33% or 4/12) MUVEs (33.33% or 4/12)	Avatars (41.67% or 5/12)	Multichannel communication (50.00% or 6/12)	Social engagement (66.67% or 8/12)	Communication skills (91.67% or 11/12)	
	Cognitive skills (Q17 & Q18)	Desktop (33.33% or 4/12)	Real-time interaction (33.33% or 4/12) 1st user point of view (33.33% or 4/12)	Modeling & simulation (50.00% or 6/12)	Inquiry & experimentation (50.00% or 6/12)	Cognitive skills (83.33% or 10/12)	
	Daily living/ Functional skills (Q19 & Q20)	Augmentative Reality (41.67% or 5/12)	Presence (25.00% or 3/12) Avatars (25.00% or 3/12)	Modeling & simulation (50.00% or 6/12)	Real-life representation (58.33% or 7/12)	Cognitive skills (83.33% or 10/12) Motor skills	

						(83.33% or 10/12 👫)	
	Sensorimotor skills (Q21 & Q22)	Semi-immersive (50.00% or 6/12 👫)	Real-time interaction (41.67% or 5/12 👫)	Modeling & simulation (33.33% or 4/12 👫)	Gaming (50.00% or 6/12 👫)	Motor skills (83.33% or 10/12 👫) Sensory skills (83.33% or 10/12 👫)	
	Behavioral & Emotional skills (Q23 & Q24)	Semi-immersive (33.33% or 4/12 👫)	Avatars (50.00% or 6/12 👫)	Collaboration & cooperation (41.67% or 5/12 👫)	Real-life representation (33.33% or 4/12 👫)	Communication skills (83.33% or 10/12 👫)	

6.3.3 Results of Round 2: Profile -3, Severe ASD with ID

Twelve out of the 13 participants in the study's Round 2 completed the 12 questions (Q25-Q36) regarding individuals with severe ASD and ID (Profile 3). The modes from the data collected are shown in Table 6.4.

Table 6.4 Modes of the data collected from Round 2 for individuals with severe ASD and ID (Profile -3)

Profile – 3:
Severe ASD with ID

		VR Combination				N_b=12 experts
		VR system	**VR affordances**	**VR learning affordances**	**VR task category**	**ISSS**
Tasks	**Social skills (Q25 & Q26)**	Desktop (25.00% or 3/12)	Avatars (25.00% or 3/12)	Modeling & simulation (33.33% or 4/12)	Social engagement (33.33% or 4/12)	Communication skills (58.33% or 7/12)
	Communication skills (Q27 & Q28)	Desktop (33.33% or 4/12)	Avatars (33.33% or 4/12)	Modeling & simulation (25.00% or 3/12) Multichannel communication (25.00% or 3/12)	Gaming (33.33% or 4/12)	Communication skills (66.67% or 8/12)
	Cognitive skills (Q29 & Q30)	Desktop (41.67% or 5/12)	Real-time interaction (41.67% or 5/12)	Modeling & simulation (25.00% or 3/12) Multichannel communication (25.00% or 3/12)	Gaming (41.67% or 5/12)	Computer skills (66.67% or 8/12)
	Daily living/ Functional skills (Q31 & Q32)	Semi-immersive (25.00% or 3/12)	Real-time interaction (25.00% or 3/12) Avatars	Modeling & simulation (33.33% or 4/12)	Real-life representation (41.67% or 5/12)	Motor skills (66.67% or 8/12)

Modes

			(25.00% or 3/12 🧑‍🤝‍🧑)				
	Sensorimotor skills (Q33 & Q34)	Semi-immersive (25.00% or 3/12 🧑‍🤝‍🧑) Augmentative Reality (25.00% or 3/12 🧑‍🤝‍🧑)	Real-time interaction (33.33% or 4/12 🧑‍🤝‍🧑)	Modeling & simulation (41.67% or 5/12 🧑‍🤝‍🧑)	Gaming (33.33% or 4/12 🧑‍🤝‍🧑) Interaction w/content (33.33% or4/12 🧑‍🤝‍🧑)	Motor skills (66.67% or 8/12 🧑‍🤝‍🧑) Sensory skills (66.67% or 8/12 🧑‍🤝‍🧑)	
	Behavioral & Emotional skills (Q35 & Q36)	Desktop (25.00% or 3/12 🧑‍🤝‍🧑)	Real-time interaction (33.33% or 4/12 🧑‍🤝‍🧑) Avatars (33.33% or 4/12 🧑‍🤝‍🧑)	Modeling & simulation (50.00% or 6/12 🧑‍🤝‍🧑)	Real-life representation (33.33% or 4/12 🧑‍🤝‍🧑)	Motor skills (58.33% or 7/12 🧑‍🤝‍🧑)	

6.3.4 Results of Round 2: Profile -4, Severe ASD without ID

Twelve out of the 13 participants of the study's Round 2 completed the 12 questions (Q37-Q48) regarding individuals with severe ASD and without ID (Profile-4). The modes from the data collected are shown in Table 6.5.

Table 6.5 Modes of the data collected from Round 2 for individuals with severe ASD and without ID (Profile - 4)

Profile – 4:
Severe ASD without ID

	VR Combination				N_b=12 experts
Tasks	**VR system**	**VR affordances**	**VR learning affordances**	**VR task category**	**ISSS** (Modes)
Social skills (Q37 & Q38)	Desktop (33.33% or 4/12)	Real-time interaction (50.00% or 6/12)	Modeling & simulation (41.67% or 5/12)	Social engagement (41.67% or 5/12)	Communication skills (66.67% or 8/12) Computer skills (66.67% or 8/12)
Communication skills (Q39 & Q40)	Desktop (33.33% or 4/12)	Real-time Interaction (25.00% or 3/12) Avatars (25.00% or 3/12) 1st user point of view (25.00% or 3/12)	Collaboration & cooperation (33.33% or 4/12)	Interaction w/ content (33.33% or 4/12) Social engagement (33.33% or 4/12)	Communication skills (75.00% or 9/12)
Cognitive skills (Q41 & Q42)	Desktop (41.67% or 5/12)	1st user point of view (33.33% or 4/12)	Modeling & simulation (41.67% or 5/12)	Gaming (41.67% or 5/12) Interaction w/ content (41.67% or 5/12)	Computer skills (83.33% or 10/12)
Daily living/	Full-immersive (33.33% or 4/12)	Real-time interaction	Modeling & simulation	Gaming (33.33% or 4/12)	Motor skills

	Functional skills (Q43 & Q44)		(25.00% or 3/12) Immersion (25.00% or 3/12) Presence (25.00% or 3/12)	(41.67% or 5/12)	Real-life representation (33.33% or 4/12) Interaction w/ content (33.33% or 4/12)	(66.67% or 8/12) Computer skills (66.67% or 8//12)	
	Sensorimotor skills (Q45 & Q46)	Full-immersive (50.00% or 6/12)	Real-time Interaction (41.67% or 5/12)	Modeling & Simulation (58.33% or 7/12)	Interaction w/content (33.33% or 4/12)	Motor skills (75.00% or 9/12)	
	Behavioral & Emotional skills (Q47 & Q48)	Desktop (25.00% or 3/12) Full-immersive (25.00% or 3/12) MUVES (25.00% or 3/12)	Avatars (41.67% or 5/12)	Collaboration & cooperation (41.67% or 5/12)	Social engagement (33.33% or 4/12) Interaction w/ content (33.33% or 4/12)	Computer skills (66.67% or 8/12)	

6.4 Results of Round 3

Regarding the statistical analysis of Round 3, it was similar to what was previously described for Round 2. In this round, eight experts fully participated, bringing the response rate for Round 3 to 61.53% (i.e., 8 out of 13 experts who participated in Round 2). Their demographic characteristics (i.e., country, educational background, professional position, work setting, and experience) are also included to provide a further perspective on this round's results (Figures 6.14-6.18).

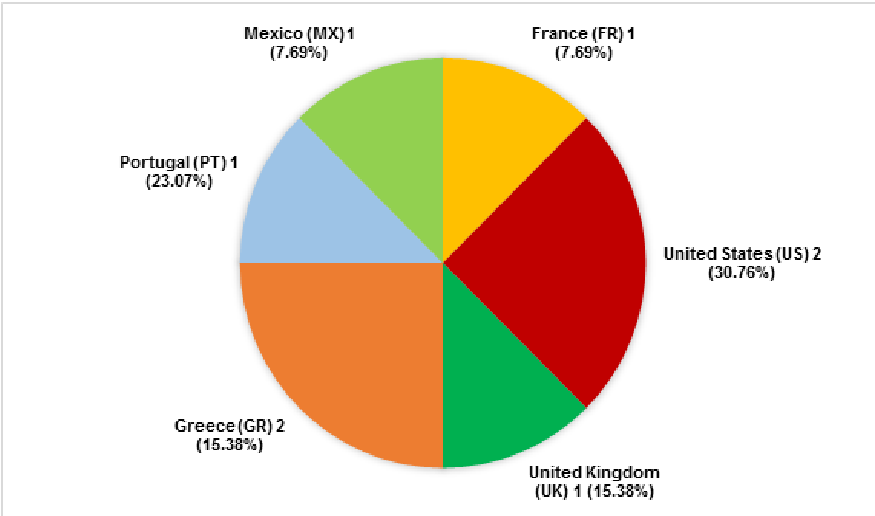


Figure 6.14 Round 3, experts' country of professional origin (N_{R3}=8)

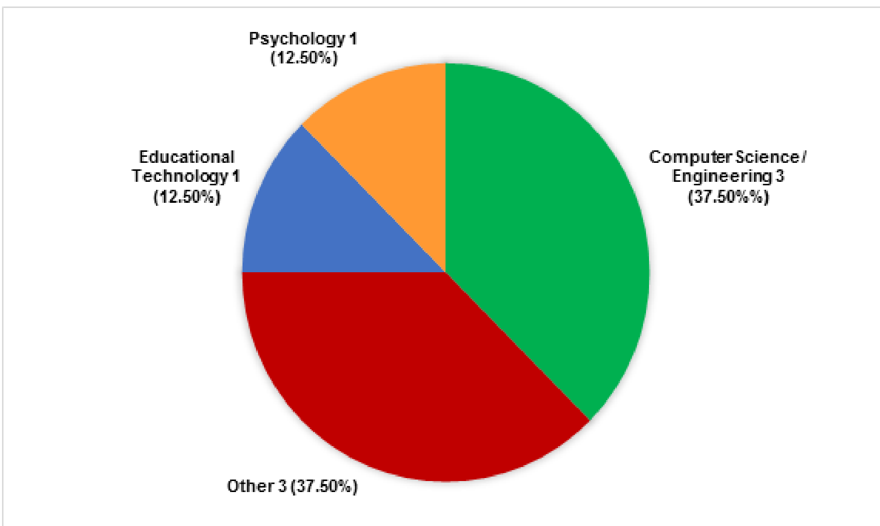


Figure 6.15 Round 3, experts' educational background (N_{R3}=8)

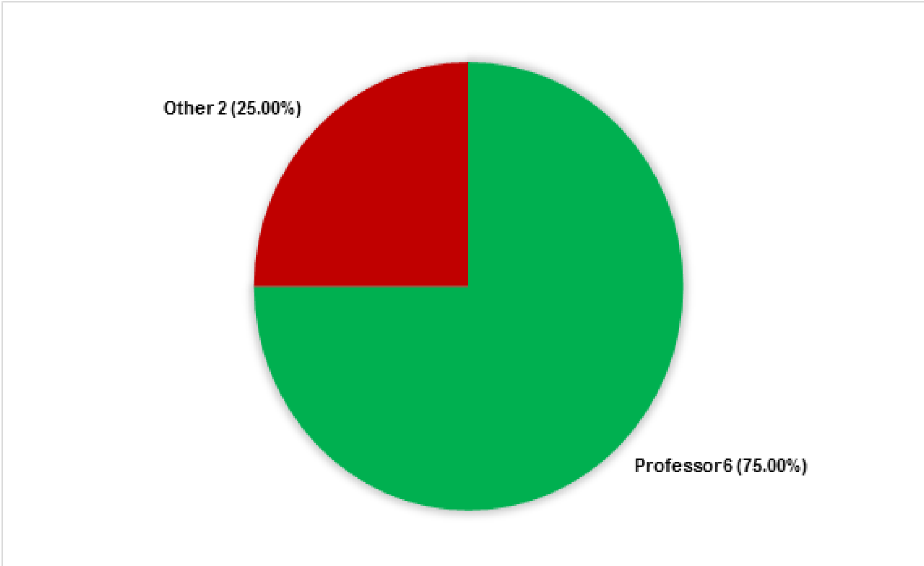


Figure 6.16 Round 3, experts' professional position (N_{R3}=8)

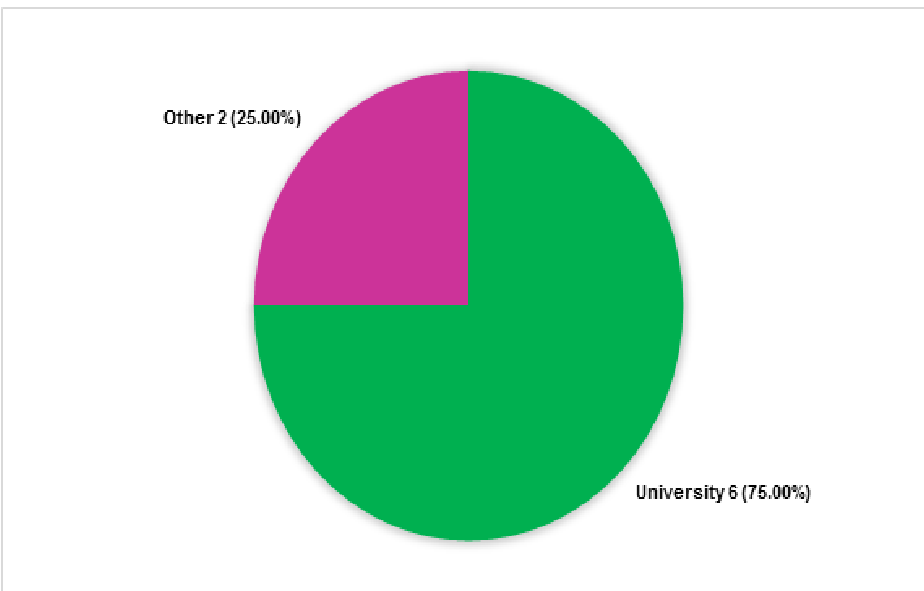


Figure 6.17 Round 3, experts' work setting (N_{R3}=8)

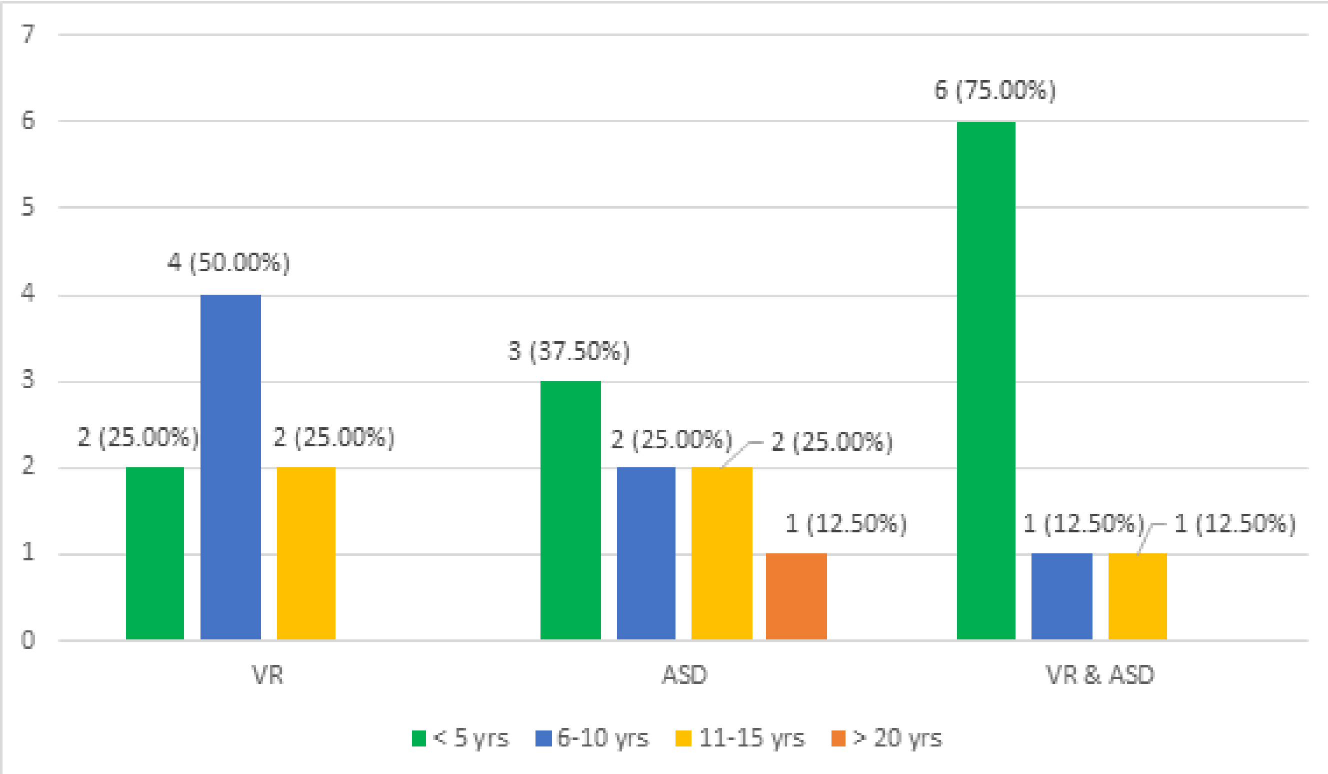


Figure 6.18 Round 3, experts' experience with VR, ASD, and VR & ASD (N_{R3}=8)

The participating experts rated a total of 148 statements on a 5-point Likert scale. The pertinent statements were derived from Round 2 and were the VR combinations and pertinent ISSS (Individual's Specific Skill Set) with the highest modes. In the same vein as Round 2, Round 3's results are depicted in four tables, one for each of the four selected clinical profiles (Profiles to 4). The statements are color-coded per targeted skill(s) and based on the most frequent VR combinations and pertinent ISSS.

Regarding this study's consensus, according to Evans (1997) and Keeney, McKenna and Hasson (2011), "the terms agreement and consensus are essentially two different ideologies. Is there a difference between the extent to which each participant agrees with the issue under consideration and the extent to which participants agree with each other? When reporting findings, few studies do so in the context of these different principles. Most researchers prefer instead to rely upon participants agreeing with each other. Yet it is important to note that the extent to which participants agree with each other does not mean that consensus exists, nor does it mean that the 'correct answer has been found" (Keeney, McKenna and Hasson, 2011, p.92).

Thus, for the purpose of this study, a consensus of at least 75% was required for each item. It is noteworthy that Sumison (1998), McKenna et al. (2002), and Keeney, McKenna and Hasson (2011) reported that a consensus level of at least 70% is a strong cut-off point. Thus, statements with an 'Agree' and 'Strongly Agree' rating that collectively achieve a minimum consensus of 75% would be included in the suggested design guidelines for virtual environments for individuals with ASD. Out of the 148 administered statements, 69 statements achieved the required consensus level (46.62%), with 40 statements receiving a high consensus level (27.02%).

6.4.1 Results of Round 3: Profile -1, Mild ASD with ID

All eight participants of Round-3 rated (5-point Likert scale) 36 statements regarding the VR combinations and the pertinent ISSS that would be most beneficial for individuals with mild ASD and ID (Profile-1). The 'Agree' and 'Strongly Agree' ratings are depicted in Table 6.6. When their total sum reached a minimum of 75% consensus, it was highlighted (yellow highlight: statements with a high consensus rate, i.e., 85% or higher; grey highlight: statements with the minimum consensus rate, i.e., 75%). The statements that met the required level of consensus would be included in the proposed design guidelines. Out of the 36 statements, 20 met the consensus necessary level (55.55%), with 12 receiving high consensus rates (33.33%).

Table 6.6 Agree/Strongly Agree ratings and experts' consensus on statements from Round 3 for individuals with mild ASD and ID (Profile - 1).

		Profile – 1: **Mild ASD with ID**	**Agree**	**Strongly Agree**	**Consensus (SA/SA+A)**
Social skills tasks	**VR combo (Q1)**	Semi immersive (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q1)	75.00% (6)	25.00% (2)	100.00% (8) 25.00% (2)
	ISSS (Q1.1 & Q1.2)	Cognitive skills (Q1.1)	37.50% (3)	25.00% (2)	62.50% (5) 25.00% (2)
		Motor skills (Q1.2)	12.50% (1)	37.50% (3)	50.00% (4) 37.50% (3)
	VR combo (Q2)	Semi immersive (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q2)	50.00% (4)	25.00% (2)	75.00% (6) 25.00% (2)
	ISSS (Q2.1 & Q2.2)	Cognitive skills (Q2.1)	25.00% (2)	25.00% (2)	50.00% (4) 25.00% (2)
		Motor skills (Q2.2)	25.00% (2)	25.00% (2)	50.00% (4) 25.00% (2)
Communication skills tasks	**VR combo (Q3)**	Full immersive (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q3)	37.50% (3)	50.00% (4)	87.50% (7) 50.00% (4)
	ISSS (Q3.1)	Communication skills (Q3.1)	25.00% (2)	50.00% (4)	75.00% (6) 50.00% (4)
	VR combo (Q4)	Full immersive (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance)	75.00% (6)	12.50% (1)	87.50% (7)

		Social engagement (VR task/activity category) (Q4)			12.50% (1)
	ISSS (Q4.1)	Communication skills (Q4.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q5)	Full immersive (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q5)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	ISSS (Q5.1)	Communication skills (Q5.1)	50.00% (4 👫)	25.00% (2 👫)	75.00% (6) 25.00% (2)
	VR combo (Q6)	MUVEs (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q6)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	ISSS (Q6.1)	Communication skills (Q6.1)	37.50% (3 👫)	0.00% (0 👫)	37.50% (3) 0.00% (0)
	VR combo (Q7)	MUVEs (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q7)	62.50% (5 👫)	25.00% (2 👫)	87.50% (7) 25.00% (2)
	ISSS (Q7.1)	Communication skills (Q7.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q8)	MUVEs (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q8)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
	ISSS (Q8.1)	Communication skills (Q8.1)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
	VR combo (Q9)	Augmented Reality (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q9)	50.00% (4 👫)	37.50% (3 👫)	87.50% (7) 37.50% (3)
	ISSS	Communication skills (Q9.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5)

	(Q9.1)				25.00% (2)
	VR combo (Q10)	Augmented Reality (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q10)	62.50% (5 👫)	25.00% (2 👫)	87.50% (7) 25.00% (2)
	ISSS (Q10.1)	Communication skills (Q10.1)	50.00% (4 👫)	25.00% (2 👫)	75.00% (6) 25.00% (2)
	VR combo (Q11)	Augmented Reality (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task/activity category) (Q11)	75.00% (6 👫)	12.50% (1 👫)	87.50% (7) 12.50% (1)
	ISSS (Q11.1)	Communication skills (Q11.1)	75.00% (6 👫)	0.00% (0 👫)	75.00% (6) 0.00% (0)
Cognitive skills tasks	**VR combo (Q12)**	Desktop (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Inquiry & experimentation (VR task/activity category) (Q12)	50.00% (4 👫)	37.50% (3 👫)	87.50% (7) 37.50% (3)
	ISSS (Q12.1)	Computer skills (Q12.1)	62.50% (5 👫)	12.50% (1 👫)	75.00% (6) 12.5% (1)
	VR combo (Q13)	Desktop (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task/activity category) (Q13)	62.50% (5 👫)	37.50% (3 👫)	100.00% (8) 37.50% (3)
	ISSS (Q13.1)	Computer skills (Q13.1)	62.50% (5 👫)	12.50% (1 👫)	75.00% (6) 12.50% (1)
Daily living/functional life skills tasks	**VR combo (Q14)**	Augmented Reality (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Real life representation (VR task/activity category) (Q14)	37.50% (3 👫)	50.00% (4 👫)	87.50% (7) 50.00% (4)
	ISSS (Q14.1)	Motor skills (Q14.1)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
	VR combo	Full immersive (VR system)	75.00% (6 👫)	12.50% (1 👫)	87.50% (7)

Sensorimotor skills tasks	(Q15)	Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task/activity category) (Q15)			12.50% (1)
	ISSS (Q15.1)	Motor skills (Q15.1)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.5% (1)
	VR combo (Q16)	Semi immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task/activity category) (Q16)	62.50% (5 👫)	25.00% (2 👫)	87.50% (7) 25.00% (2)
	ISSS (Q16.1)	Motor skills (Q16.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
Behavioral & emotional skills tasks	VR combo (Q17)	Full immersive (VR system) Presence (VR affordance) Modeling & simulation (VR learning affordance) Social engagement (VR task/activity category) (Q17)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6) 37.50% (3)
	ISSS (Q17.1)	Communication skills (Q17.1)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)

6.4.2 Results of Round 3: Profile-2, Mild ASD without ID

All eight participants of Round 3 rated (5-point Likert scale) 23 statements regarding the VR combinations and the pertinent ISSS that would be most beneficial for individuals with mild ASD and without ID (Profile-2). The ‘Agree’ and ‘Strongly Agree’ ratings are depicted in Table 6.7. When their total sum reached a minimum of 75% consensus, it was highlighted, and the statements that met the required level of consensus would be included in the proposed design guidelines. Out of the 23 statements, 18 met the level of consensus needed (78.26%), with 11 receiving high consensus rates (47.82%).

Table 6.7 Agree/Strongly Agree ratings and experts' consensus on statements from Round 3 for individuals with mild ASD and without ID (Profile - 2).

Profile – 2: **Mild ASD without ID**			**Agree**	**Strongly Agree**	**Consensus (SA/SA+A)**
Social skills tasks	**VR combo (Q18)**	MUVEs (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q18)	50.00% (4)	50.00% (4)	100.00% (8) 50.00% (4)
	ISSS (Q18.1)	Communication skills (Q18.1)	62.50% (5)	12.50% (1)	75.00% (6) 12.50% (1)
	VR combo (Q19)	MUVEs (VR system) Presence (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q19)	37.50% (3)	50.00% (4)	87.50% (7) 50.00% (4)
	ISSS (Q19.1)	Communication skills (Q19.1)	50.00% (4)	25.00% (2)	75.00% (6) 25.00% (2)
Communication skills tasks	**VR combo (Q20)**	Full immersive (VR system) Avatars (VR affordance) Multichannel communication (VR learning affordance) Social engagement (VR task activity/category) (Q20)	12.50% (1)	62.50% (5)	75.00% (6) 62.50% (5)
	ISSS (Q20.1)	Communication skills (Q20.1)	12.50% (1)	37.50% (3)	50.00% (4) 37.50% (3)
	VR combo (Q21)	MUVEs (VR system) Avatars (VR affordance) Multichannel communication (VR learning affordance) Social engagement (VR task activity/category) (Q21)	37.50% (3)	50.00% (4)	87.50% (7) 50.00% (4)
	ISSS (Q21.1)	Communication skills (Q21.1)	62.50% (5)	25.00% (2)	87.50% (7) 25.00% (2)
Cognitive	**VR combo**	Desktop (VR system)	25.00% (2)	75.00% (6)	100.00% (8)

skills tasks	**(Q22)**	Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Inquiry & experimentation (VR task activity/category) (Q22)			75.00% (6)
	ISSS (Q22.1)	Cognitive skills (Q22.1)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6) 37.50% (3)
	VR combo (Q23)	Desktop (VR system) 1st user point of view (VR affordance) Modeling & simulation (VR learning affordance) Inquiry & experimentation (VR task activity/category) (Q23)	25.00% (2 👫)	62.50% (5 👫)	87.50% (7) 62.50% (5)
	ISSS (Q23.1)	Cognitive skills (Q23.1)	25.00% (2 👫)	50.00% (4 👫)	75.00% (6) 50.00% (4)
Daily living/functional life skills tasks	**VR combo (Q24)**	Augmented Reality (VR system) Presence (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q24)	12.50% (1 👫)	75.00% (6 👫)	87.50% (7) 75.00% (6)
	ISSS (Q24.1&Q24.2)	Cognitive skills (Q24.1)	25.00% (2 👫)	25.00% (2 👫)	50.00% (4) 25.00% (2)
		Motor skills (Q24.2)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q25)	Augmented Reality (VR system) Avatars (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q25)	37.50% (3 👫)	50.00% (4 👫)	87.50% (7) 50.00% (4)
	ISSS (Q25.1&Q25.2)	Cognitive skills (Q25.1)	25.00% (2 👫)	37.50% (3 👫)	62.50% (5) 37.50% (3)
		Motor skills (Q25.2)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)
Sensorimotor skills tasks	**VR combo (Q26)**	Semi immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q26)	37.50% (3 👫)	62.50% (5 👫)	100.00% (8) 62.50% (5)
	ISSS	Motor skills (Q26.1)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6)

	(Q26.1&Q26.2)				37.50% (3)
		Sensory skills (Q26.2)	50.00% (4 👫)	25.00% (2 👫)	75.00% (6) 25.00% (2)
Behavioral & emotional skills tasks	**VR combo (Q27)**	Semi immersive (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Real-life representation (VR task activity/category) (Q27)	12.50% (1 👫)	75.00% (6 👫)	87.50% (7) 75.00% (6)
	ISSS (Q27.1)	Communication skills (Q27.1)	50.00% (4 👫)	37.50% (3 👫)	87.50% (7) 37.50% (3)

6.4.3 Results of Round 3: Profile-3, Severe ASD with ID

All eight participants from Round 3 rated (5-point Likert scale) 29 statements regarding the VR combinations and the pertinent ISSS that would be most beneficial for individuals with severe ASD and with ID (Profile-3). The ‘Agree’ and ‘Strongly Agree’ ratings are depicted in Table 6.8. When their total sum reached a minimum of 75% consensus, it was highlighted, and the statements that met the required level of consensus would be included in the proposed design guidelines. It is noteworthy that none of the 29 statements met the level of consensus needed.

Table 6.8 Agree/Strongly Agree ratings and experts' consensus on statements from Round 3 for individuals with severe ASD and ID (Profile -3).

Profile – 3: **Severe ASD with ID**			**Agree**	**Strongly Agree**	**Consensus (SA/SA+A)**
Social skills tasks	**VR combo (Q28)**	Desktop (VR system) Avatars (VR affordance) Modeling & simulation (VR learning affordance) Social engagement (VR task activity/category) (Q28)	25.00% (2)	12.50% (1)	37.50% (3) 12.50% (1)
	ISSS (Q28.1)	Communication skills (Q28.1)	37.50% (3)	25.00% (2)	62.5% (5) 25.00% (2)
Communication skills tasks	**VR combo (Q29)**	Desktop (VR system) Avatars (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q29)	12.50% (1)	12.50% (1)	25.00% (2) 12.50% (1)
	ISSS (Q29.1)	Communication skills (Q29.1)	12.50% (1)	25.00% (2)	37.50% (3) 25.00% (2)
	VR combo (Q30)	Desktop (VR system) Avatars (VR affordance) Multichannel communication (VR learning affordance) Gaming (VR task activity/category) (Q30)	12.50% (1)	25.00% (2)	37.50% (3) 25.00% (2)
	ISSS (Q30.1)	Communication skills (Q30.1)	37.50% (3)	12.50% (1)	50.00% (4) 12.50% (1)
Cognitive skills tasks	**VR combo (Q31)**	Desktop (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q31)	25.00% (2)	25.00% (2)	50.00% (4) 25.00% (2)
	ISSS (Q31.1)	Computer skills (Q31.1)	50.00% (4)	0.00% (0)	50.00% (4) 0.00% (0)
	VR combo	Desktop (VR system)	12.50% (1)	12.50% (1)	25.00% (2)

	(Q32)	Real-time interaction (VR affordance) Multichannel communication (VR learning affordance) Gaming (VR task activity/category)			12.50% (1)
	ISSS (Q32.1)	Computer skills (Q32)	37.50% (3 👫)	0.00% (0 👫)	37.50% (3) 0.00% (0)
Daily living/functional life skills tasks	**VR combo (Q33)**	Semi immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q33)	12.50% (1 👫)	37.50% (3 👫)	50.00% (4) 37.50% (3)
	ISSS (Q33.1)	Motor skills (Q33.1)	12.50% (1 👫)	12.50% (1 👫)	25.00% (2) 12.50% (1)
	VR combo (Q34)	Semi immersive (VR system) Avatars (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q34)	0.00% (0 👫)	37.50% (3 👫)	37.50% (3) 37.50% (3)
	ISSS (Q34.1)	Motor skills (Q34.1)	37.50% (3 👫)	0.00% (0 👫)	37.50% (3) 0.00% (0)
Sensorimotor skills tasks	**VR combo (Q35)**	Semi immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q35)	12.50% (1 👫)	25.00% (2 👫)	37.50% (3) 25.00% (2)
	ISSS (Q35.1)	Motor skills (Q35.1)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
	ISSS (Q35.2)	Sensory skills (Q35.2)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)
	VR combo (Q36)	Semi immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q36)	12.50% (1 👫)	25.00% (2 👫)	37.50% (3) 25.00% (2)
	ISSS (Q36.2)	Sensory skills (Q36.2)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)

	VR combo (Q37)	Augmented Reality (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q37)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	ISSS (Q37.1)	Motor skills (Q37.1)	25.00% (2 👫)	0.00% (0 👫)	25.00% (2) 0.00% (0)
	ISSS (Q37.2)	Sensory skills (Q37.2)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
	VR combo (Q38)	Augmented Reality (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q38)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	ISSS (Q38.1)	Motor skills (Q38.1)	25.00% (2 👫)	12.50% (1 👫)	37.50% (3) 12.50% (1)
	ISSS (Q38.2)	Sensory skills (Q38.2)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
Behavioral & emotional skills tasks	**VR combo (Q39)**	Desktop (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q39)	12.50% (1 👫)	25.00% (2 👫)	37.50% (3) 25.00% (2)
	ISSS (Q39.1)	Motor skills (Q.39.1)	12.50% (1 👫)	12.50% (1 👫)	25.00% (2) 12.50% (1)
	VR combo (Q40)	Desktop (VR system) Avatars (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q40)	25.00% (2 👫)	12.50% (1 👫)	37.50% (3) 12.50% (1)
	ISSS (Q40.1)	Motor skills (Q40.1)	12.50% (1 👫)	12.50% (1 👫)	25.00% (2) 12.50% (1)

6.4.4 Results of Round 3: Profile-4, Severe ASD without ID

All eight participants in Round 3 rated 60 statements (on a 5-point Likert scale) regarding the VR combinations and the pertinent ISSS that would be most beneficial for individuals with severe ASD and without ID (Profile-4). The ‘Agree’ and ‘Strongly Agree’ ratings are depicted in Table 6.9. When their total sum reached a minimum of 75% consensus, it was highlighted, and the statements that met the required level of consensus would be included in the proposed design guidelines. Out of the 60 statements, 31 met the required consensus level (51.66%), with 17 receiving high consensus rates (28.33%).

Table 6.9 Agree/Strongly Agree ratings and experts' consensus on statements from Round 3 for individuals with severe ASD and without ID (Profile- 4).

Profile – 4: **Severe ASD without ID**			**Agree**	**Strongly Agree**	**Consensus (SA/SA+A)**
Social skills tasks	**VR combo (Q41)**	Desktop (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Social engagement (VR task activity/category) (Q41)	62.50% (5)	25.00% (2)	87.50% (7) 25.00% (2)
	ISSS (Q41.1)	Communication skills (Q41.1)	62.50% (5)	12.50% (1)	75.00% (6) 12.50% (1)
	ISSS (Q41.2)	Computer skills (Q41.2)	50.00% (4)	25.00% (2)	75.00% (6) 25.00% (2)
Communication skills tasks	**VR combo (Q42)**	Desktop (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q42)	50.00% (4)	37.50% (3)	87.50% (7) 37.50% (3)
	ISSS (Q42.1)	Communication skills (Q42.1)	62.50% (5)	0.00% (0)	62.50% 0.00% (0)
	VR combo (Q43)	Desktop (VR system) Real-time interaction (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q43)	37.50% (3)	50.00% (4)	87.50% (7) 50.00% (4)
	ISSS (Q43.1)	Communication skills (Q43.1)	50.00% (4)	12.50% (1)	62.50% (5) 12.50% (1)
	VR combo (Q44)	Desktop (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q44)	37.50% (3)	37.50% (3)	75.00% (6) 37.50% (3)
	ISSS	Communication skills (Q44.1)	50.00% (4)	0.00% (0)	50.00% (4)

	(Q44.1)				0.00% (0)
	VR combo (Q45)	Desktop (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q45)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6) 37.50% (3)
	ISSS (Q45.1)	Communication skills (Q45.1)	50.00% (4 👫)	0.00% (0 👫)	50.00% (4) 0.00% (0)
	VR combo (Q46)	Desktop (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q46)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50%(1)
	ISSS (Q46.1)	Communication skills (Q46.1)	50.00% (4 👫)	0.00% (0 👫)	50.00% (4) 0.00% (0)
	VR combo (Q47)	Desktop (VR system) 1st user point of view (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q47)	87.50% (7 👫)	0.00% (0 👫)	87.50% (7) 0.00% (0)
	ISSS (Q47.1)	Communication skills (Q47.1)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)
Cognitive skills tasks	**VR combo (Q48)**	Desktop (VR system) 1st user point of view (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q48)	75.00% (6 👫)	12.50% (1 👫)	87.50% (7) 12.50% (1)
	ISSS (Q48.1)	Computer skills (Q48.1)	25.00% (2 👫)	12.50% (1 👫)	37.50% (3) 12.50% (1)
	VR combo (Q49)	Desktop (VR system) 1st user point of view (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q49)	50.00% (4 👫)	25.00% (2 👫)	75.00% (6) 25.00% (2)
	ISSS (Q49.1)	Computer skills (Q49.1)	25.00% (2 👫)	37.50% (3 👫)	62.50% (5) 37.50% (3)

Daily living/functional life skills tasks	**VR combo (Q50)**	Full immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q50)	25.00% (2 👫)	50.00% (4 👫)	75.00% (6) 50.00% (4)
	ISSS (Q50.1)	Motor skills (Q50.1)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)
	ISSS (Q50.2)	Computer skills (Q50.2)	12.50% (1 👫)	25.00% (2 👫)	37.50% (3) 25.00% (2)
	VR combo (Q51)	Full immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q51)	62.50% (5 👫)	25.00% (2 👫)	87.50% (7) 25.00% (2)
	ISSS (Q51.1)	Motor skills (Q51.1)	62.50% (5 👫)	0.00% (0 👫)	62.50% (5) 0.00% (0)
	ISSS (Q51.2)	Computer skills (Q51.2)	12.50% (1 👫)	25.00% (2 👫)	37.50% (3) 25.00% (2)
	VR combo (Q52)	Full immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q52)	50.00% (4 👫)	25.00% (2 👫)	75.00% (6) 25.00% (2)
	ISSS (Q52.1)	Motor skills (Q52.1)	50.00% (4 👫)	0.00% (0 👫)	50.00% (4) 0.00% (0)
	ISSS (Q52.2)	Computer skills (Q52.2)	25.00% (2 👫)	25.00% (2 👫)	50.00% (4) 25.00% (2)
	VR combo (Q53)	Full immersive (VR system) Immersion (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q53)	62.50% (5 👫)	37.50% (3 👫)	100.00% (8) 37.50% (3)
	ISSS (Q53.1)	Motor skills (Q53.1)	75.00% (6 👫)	0.00% (0 👫)	75.00% (6) 0.00% (0)

	ISSS (Q53.2)	Computer skills (Q53.2)	25.00% (2 👫)	37.50% (3 👫)	62.50% (5) 37.50% (3)
	VR combo (Q54)	Full immersive (VR system) Immersion (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q54)	62.50% (5 👫)	37.50% (3 👫)	100.00% (8) 37.50% (3)
	ISSS (Q54.1)	Motor skills (Q54.1)	62.50% (5 👫)	12.50% (1 👫)	75.00% (6) 12.50% (1)
	ISSS (Q54.2)	Computer skills (Q54.2)	25.00% (2 👫)	37.50% (3 👫)	62.50% (5) 37.50% (3)
	VR combo (Q55)	Full immersive (VR system) Immersion (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q55)	37.50% (3 👫)	50.00% (4 👫)	87.50% (7) 50.00% (4)
	ISSS (Q55.1)	Motor skills (Q55.1)	50.00% (4 👫)	12.50% (1 👫)	62.50% (5) 12.50% (1)
	ISSS (Q55.2)	Computer skills (Q55.2)	12.50% (1 👫)	37.50% (3 👫)	50.00% (4) 37.50% (3)
	VR combo (Q56)	Full immersive (VR system) Presence (VR affordance) Modeling & simulation (VR learning affordance) Gaming (VR task activity/category) (Q56)	37.50% (3 👫)	62.50% (5 👫)	100.00% (8) 62.50% (5)
	ISSS (Q56.1)	Motor skills (Q56.1)	62.50% (5 👫)	12.50% (1 👫)	75.00% (6) 12.50% (1)
	ISSS (Q56.2)	Computer skills (Q56.2)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q57)	Full immersive (VR system) Presence (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q57)	62.50% (5 👫)	37.50% (3 👫)	100.00% (8) 37.50% (3)
	ISSS	Motor skills (Q57.1)	75.00% (6 👫)	0.00% (0 👫)	75.00% (6)

	(Q57.1)				0.00% (0)
	ISSS (Q57.2)	Computer skills (Q57.2)	12.50% (1 👫)	50.00% (4 👫)	62.50% (5) 50.00% (4)
	VR combo (Q58)	Full immersive (VR system) Presence (VR affordance) Modeling & simulation (VR learning affordance) Real-life representation (VR task activity/category) (Q58)	50.00% (4 👫)	50.00% (4 👫)	100.00% (8) 50.00% (4)
	ISSS (Q58.1)	Motor skills (Q58.1)	62.50% (5 👫)	12.50% (1 👫)	75.00% (6) 12.50% (1)
	ISSS (Q58.2)	Computer skills (Q58.2)	12.50% (1 👫)	37.50% (3 👫)	50.00% (4) 37.50% (3)
Sensorimotor skills tasks	**VR combo (Q59)**	Full immersive (VR system) Real-time interaction (VR affordance) Modeling & simulation (VR learning affordance) Interaction with content (VR task activity/category) (Q59)	75.00% (6 👫)	25.00% (2 👫)	100.00% (8) 25.00% (2)
	ISSS (Q59.1)	Motor skills (Q59.1)	87.50% (7 👫)	0.00% (0 👫)	87.50% (7) 0.00% (0)
Behavioral & emotional skills tasks	**VR combo (Q60)**	Desktop (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q60)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6) 37.50% (3)
	ISSS (Q60.1)	Computer skills (Q60.1)	0.00% (0 👫)	50.00% (4 👫)	50.00% (4) 50.00% (4)
	VR combo (Q61)	Desktop (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q61)	50.00% (4 👫)	37.50% (3 👫)	87.50% (7) 37.50% (3)
	ISSS (Q61.1)	Computer skills (Q61.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q62)	Full immersive (VR system) Avatars (VR affordance)	37.50% (3 👫)	37.50% (3 👫)	75.00% (6)

		Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q62)			37.50% (3)
	ISSS (Q62.1)	Computer skills (Q62.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q63)	Full immersive (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q63)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	ISSS (Q63.1)	Computer skills (Q63.1)	12.50% (1 👫)	37.50% (3 👫)	50.00% (4) 37.50% (3)
	VR combo (Q64)	MUVEs (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Interaction with content (VR task activity/category) (Q64)	50.00% (4 👫)	50.00% (4 👫)	100.00% (8) 50.00% (4)
	ISSS (Q64.1)	Computer skills (Q64.1)	37.50% (3 👫)	25.00% (2 👫)	62.50% (5) 25.00% (2)
	VR combo (Q65)	MUVEs (VR system) Avatars (VR affordance) Collaboration & cooperation (VR learning affordance) Social engagement (VR task activity/category) (Q65)	37.50% (3 👫)	50.00% (4 👫)	87.50% (7) 50.00% (4)
	ISSS (Q65.1)	Computer skills (Q65.1)	37.50% (3 👫)	12.50% (1 👫)	50.00% (4) 12.50% (1)

Chapter 7

DISCUSSION

7.1 Introduction

This work aimed to propose a comprehensive framework of design guidelines for virtual environments tailored to individuals with autism spectrum disorder. It offers an interconnected VR technology and an affordance-based approach, incorporating a user-centered component. The goal of the suggested design guidelines was for the involved components to work together and provide users with a beneficial and inclusive training experience.

In this chapter, we present the design guidelines that participating experts were able to reach consensus on (i.e., Round 3's findings). Before elaborating on them and as mentioned in previous chapters, "it is important to note that the extent to which participants agree with each other does not mean that consensus exists, nor does it mean that the 'correct answer has been found" (Keeney, McKenna and Hasson, 2011, p.92). Thus, the following design guidelines are suggestions for consideration and further (empirical) study.

The design guidelines are presented as sets for each of the four clinical profiles introduced in Round 2, i.e., mild ASD with ID (Profile-1), mild ASD without ID (Profile-2), severe ASD with ID (Profile-3), and severe ASD without ID (Profile-4). A consensus was reached for some or all of the proposed design guidelines for Profiles 1, 2, and 4. None of the proposed design guidelines for Profile-3 (severe ASD with ID) reached consensus. Regarding the design guidelines, they consisted of: a) the VR combination (i.e., VR system, VR affordance, VR learning affordance, and VR task/activity) that reached consensus, and then b) the Individuals' Specific Skills Sets (ISSSs) that also needed to reach consensus. Thus, for a design guideline to be included, the VR combination would have to reach consensus initially, and then its accompanying ISSSs would be included if they also reached consensus for that specific VR combination. Therefore, for cases where the ISSSs reached consensus but not their corresponding VR combination, they were excluded from the proposed design guidelines.

7.2 Design guidelines for Profile -1 (Mild ASD with ID)

Out of a total of 17 suggested design guidelines (i.e., 17 VR combinations and their respective 19 ISSSs) for individuals with mild ASD and with ID, 14 reached the acceptable consensus level of at least 75%. The three VR combinations that did not reach consensus were:

a) targeting ‘Communication skills’ (#5): Full immersive (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category) / ISSS: Communication skills
b) targeting ‘Communication skills’ (#6): MUVEs (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category) / ISSS: Communication skills, and
c) targeting ‘Communication skills’ (#8): MUVEs (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category) / ISSS: Communication skills.

All three design guidelines that did not reach consensus targeted the training of individuals’ communication skills, while at the same time requiring them to demonstrate an adequate level of the same skills (i.e., to receive benefits from the proposed virtual environment). This is somewhat of a paradox, which could be the reason these design guidelines did not reach consensus. This pattern aligns with literature findings as there is no adequate evidence for VR-based social communication interventions specifically designed for Profile-1 populations (Hopkins et al., 2011; Root et al., 2017). The lack of clarity found in the pertinent literature reflects broader issues, as communication skills are at times viewed in association with social skills without clear differentiation. Thus, researchers of these studies mention that the pertinent virtual applications target social-communication skills without clearly defining and differentiating between them with the terms appearing to be used in a more interchangeable manner.

Additionally, the significance and role of communication skills in the successful use of these virtual environments appear to be underreported, with a primary focus on verbal communication. For Profile-1 individuals who may have significant communication needs, alternative and augmentative communication (AAC) integration is essential (e.g., supported by PECS success in Ramachandiran et al., 2015), requiring multiple communication modalities and reduced verbal communication demands. This is something to consider in future studies and virtual applications, as there are ways to overcome these barriers through communication systems.

In reviewing the design guidelines that reached consensus, Table 7.1 lists all 17 of them (i.e., VR combinations and ISSS, when applicable).

*__Table 7.1__ Design guidelines for Profile–1 (*Mild ASD with ID)

		VR combination						
		VR system	**VR affordance**	**VR learning affordance**	**VR task/activity category**	**VR Consensus**	**ISSS**	**ISSS Consensus**
Social skills	#1	Semi immersive	Real-time interaction	Collaboration & cooperation	Social engagement	100%	Cognitive skills Motor skills	-
	#2	Semi immersive	1st user point of view	Collaboration & cooperation	Social engagement	75%	Cognitive skills Motor skills	-
Communication skills	#3	Full immersive	Real-time interaction	Collaboration & cooperation	Social engagement	87.5%	Communication skills	75%
	#4	Full immersive	Avatars	Collaboration & cooperation	Social engagement	87.5%	Communication skills	-
	#7	MUVEs	Avatars	Collaboration & cooperation	Social engagement	87.5%	Communication skills	-
	#9	Augmented Reality	Real-time interaction	Collaboration & cooperation	Social engagement	87.5%	Communication skills	-
	#10	Augmented Reality	Avatars	Collaboration & cooperation	Social engagement	87.5%	Communication skills	75%
	#11	Augmented Reality	1st user point of view	Collaboration & cooperation	Social engagement	87.5%	Communication skills	75%)
Cognitive Skills	#12	Desktop	Real-time interaction	Modeling & simulation	Inquiry & experimentation	87.5%	Computer skills	75%
	#13	Desktop	Real-time interaction	Modeling & simulation	Interaction with content	100%	Computer skills	75%
Daily living / Functional life skills	#14	Augmented Reality	Real-time interaction	Modeling & simulation	Real-life representation	87.5%	Motor skills	-
Sensorimotor skills	#15	Full immersive	Real-time interaction	Modeling & simulation	Interaction with content	87.5%	Motor skills	-
	#16	Semi immersive	Real-time interaction	Modeling & simulation	Interaction with content	87.5%	Motor skills	-
Behavioral & emotional skills	#17	Full immersive	Presence	Modeling & simulation	Social engagement	75%	Communication skills	-

Due to the heterogeneity of the pertinent studies and the individuals with autism themselves, we review the accepted design guidelines within the profile. Table 7.2 shows an overview of the design guidelines.

Table 7.2 Overview of the experts' answers for Profile-1; 82% consensus reached for the VR combinations (design guidelines).

	VR combinations ($N_{1.1}$=14, $N_{0,1.1}$=17)				
VR system	Full-immersive: 4/14	Augmented Reality: 4/14	Semi-immersive: 3/14	Desktop: 2/14	MUVEs: 1/14
VR affordances	Real-time interaction: 8/14	Avatars: 3/14	1st user point of view: 2/14	Presence: 1/14	
VR learning affordance	Collaboration & cooperation: 8/14	Modeling & simulation: 6/14			
VR task activity/category	Social engagement: 9/14	Interaction w/ content: 3/14	Real-life representation: 1/14	Inquiry & experimentation: 1/14	
	ISSS: ($N_{1.2}$=8, $N_{0,1.2}$=19)				
	Communication: 4/8	Cognitive: 2/8	Motor: 1/8	Sensory: 1/8	

Regarding the suggested VR systems, there was great diversity, with 'Full-immersive' VR systems and 'Augmented Reality' receiving the highest frequencies (4/14 each). However, critical evidence limitations must be acknowledged: studies using these technologies (Wade et al., 2016; Wade et al., 2017; Zhang et al., 2017) primarily involved high-functioning participants without intellectual disability, creating a significant mismatch of evidence to the population for Profile-1 design guidelines.

While these studies suggest that some individuals with autism can use Full-immersive VR and AR systems without significant difficulties (including relevant equipment such as HMDs for VR and goggles for AR), no studies have validated these technologies specifically for mild ASD with ID populations. Only a small number of studies contain Profile 1-relevant evidence (Hopkins et al., 2011; Root et al., 2017; Bouck et al., 2014; Strickland et al., 1996, 1997, 2007; Herring et al., 2017; Herrera et al., 2006; Ramachandiran et al., 2015; Cheng & Huang, 2012). Therefore, while these technologies appear accessible and affordable, their suitability for Profile-1 individuals requires direct empirical validation rather than generalization from higher-functioning study participants.

Regarding the VR affordances, 'Real-time interaction' received the highest consensus rates (8/14). This affordance has theoretical support in autism intervention literature, as it provides users with immediate results/responses to their actions, potentially helping them make learning connections between actions and resulting responses in what could be viewed as a cause-and-effect approach. This aligns with behavioral learning approaches showing effectiveness in both autism and intellectual disability intervention literature. However, specific validation of real-time interaction affordances for Profile-1 populations in VR contexts remains limited, and the theoretical benefits require empirical confirmation through appropriately designed studies with mild ASD and ID participants.

Regarding the VR learning affordances, two were included in this set of design guidelines, both receiving high acceptance from the panel: 'Collaboration & cooperation' (8/14) and 'Modeling & simulation' (6/14). However, critical evidence limitations need to be noted.

The strongest empirical support for Profile-1 populations comes from academic interventions: consistent findings from two small-scale studies (Root et al., 2017; Bouck et al., 2014) demonstrate that virtual manipulatives may be preferred over concrete materials for mathematical interventions. These studies employed 'Modeling & simulation' approaches with systematic scaffolding and immediate feedback, showing promise for academic skill development. However, this evidence remains constrained by very small sample sizes of 2-3 participants, restriction to mathematical content, and lack of long-term outcome data (i.e., beyond 6 months).

For 'Collaboration & cooperation' affordances, there is not sufficient evidence for Profile-1 populations. While some studies employ collaborative virtual environments for autism populations, these typically require cognitive and communication capabilities that may exceed Profile-1 characteristics. Therefore, findings should be interpreted with extreme caution given the small sample sizes, heterogeneity of participants, and lack of population-specific validation. Further empirical research is essential before clinical recommendations can be made.

Regarding the VR task activity/category, 'Social engagement' garnered the highest consensus rates (9/14). This can be attributed to the fact that numerous VR applications target social skills for autism populations generally. However, there appears to be an important disconnect in terms while expert consensus favored social engagement activities, systematic literature review found no adequate studies validating social communication interventions specifically for Profile-1 populations. The social skills training literature predominantly focuses on higher-functioning autism populations without intellectual disability. Studies reporting benefits from social engagement virtual activities typically involve participants with cognitive and communication capabilities that may exceed Profile-1 characteristics. Additionally, some studies note concerns that users sometimes respond to digital environments as if they are not "real," reporting they do not feel compelled to follow social rules as they would in everyday life. This can lead to poor performance in these tasks and raises particular concerns about skill transfer and generalization for Profile-1 populations, where transfer of learning presents additional challenges due to intellectual disability characteristics. While the theoretical appeal of social engagement activities is clear, the absence of adequate empirical evidence for Profile-1 individuals means these design guidelines should be viewed as preliminary recommendations requiring extensive validation rather than evidence-based practice standards. Future research towards Profile-1 specific intervention development and validation should be conducted before (clinical) implementation.

Lastly, regarding the ISSSs for this set of design guidelines, less than half reached consensus (8/19), with 'Communication skills' receiving the highest consensus rate (4/8). Communication skills are often underreported in participant descriptions in relevant studies. When they are mentioned, they appear synonymous/used interchangeably with verbal communication skills, while other forms of communication are not considered. This represents a significant limitation for Profile-1 populations. In existing studies, participants are typically required to have adequate communication/language skills to understand verbal directions and scenarios, with some studies requiring verbal responses to administered tasks and/or feedback after completing virtual training. This creates the paradox noted earlier where communication skills are required to access interventions seemingly designed to train communication. For Profile-1 populations who may have significant communication support needs, alternative and augmentative communication (AAC) use/consideration is essential. Empirical support for this approach comes from Ramachandiran et al. (2015), who demonstrated feasibility of PECS-based VR toilet training for children with autism requiring intensive behavioral support. This suggests that AAC-integrated virtual environments, with multiple communication modalities and reduced verbal communication demands, may be more appropriate for Profile-1 individuals than verbally-dependent systems. Thus, unlike skill sets like 'Computer skills' and 'Motor skills' that often relate to VR system and equipment use, 'Communication skills' are linked to the virtual task/activity design and overall study administration process. Future Profile-1 VR interventions should consider comprehensive communication support systems rather than assuming adequate verbal communication abilities.

7.3 Design guidelines for Profile-2 (Mild ASD without ID)

Out of a total of 10 suggested design guidelines (i.e., 10 VR combinations and their respective 13 ISSSs) for individuals with mild ASD and without ID, all 10 reached the acceptable consensus level of at least 75%. We believe that this, along with the diversity of the accepted guidelines (which will be further analyzed below), also highlights the heterogeneity of the existing studies as well as the population of individuals with autism, even when having a 'similar' clinical profile. Table 7.3 depicts all the design guidelines that reached consensus.

Table 7.3 Design guidelines for Profile-2 (Mild ASD without ID)

		VR combination						
		VR system	**VR Affordance**	**VR learning affordance**	**VR task/activity category**	**VR Consensus**	**ISSS**	**ISSS Consensus**
Social skills	#18	MUVEs	Real-time interaction	Collaboration & cooperation	Social engagement	100%	Communication skills	75%
	#19	MUVEs	Presence	Collaboration & cooperation	Social engagement	87.5%	Communication skills	75%
Communication skills	#20	Full immersive	Avatars	Multichannel communication	Social engagement	75%	Communication skills	-
	#21	MUVEs	Avatars	Multichannel communication	Social engagement	87.5%	Communication skills	87.5%
Cognitive skills	#22	Desktop	Real-time interaction	Modeling & simulation	Inquiry & experimentation	100%	Cognitive skills	75%
	#23	Desktop	1st user point of view	Modeling & simulation	Inquiry & experimentation	87.5%	Cognitive skills	75%
Daily living/ functional life skills	#24	Augmented Reality	Presence	Modeling & simulation	Real-life representation	87.5%	Cognitive skills	-
							Motor skills	-
	#25	Augmented Reality	Avatars	Modeling & simulation	Real-life representation	87.5%	Cognitive skills	-
							Motor skills	-
Sensorimotor skills	#26	Semi immersive	Real-time interaction	Modeling & simulation	Gaming	100%	Motor skills	75%
							Sensory skills	75%
Behavioral & emotional skills	#27	Semi immersive	Avatars	Collaboration & cooperation	Real-life representation	87.5%	Communication skills	87.5%

As previously mentioned, due to the heterogeneity of the pertinent studies and the individuals with autism themselves, we review the accepted design guidelines within the profile. Table 7.4 shows an overview of the design guidelines.

Table 7.4 Overview of the experts' answers for Profile-2; 100% consensus reached for the VR combinations (design guidelines).

	VR combinations ($N_{2.1}$=10, $N_{0,2.1}$=10)				
VR system	MUVEs: 3/10	Semi-immersive: 2/10	Desktop: 2/10	Augmented Reality: 2/10	Full immersive: 1/10
VR affordances	Avatars: 4/10	Real-time interaction: 3/10	Presence: 2/10	1st user point of view: 1/10	
VR learning affordance	Modeling & simulation: 5/10	Collaboration & cooperation: 3/10	Multi-channel communication: 2/10		
VR task activity/category	Social engagement: 4/10	Real-life representation: 3/10	Inquiry and experimentation: 2/10	Gaming: 1/10	
	ISSS: ($N_{2.2}$=8, $N_{0,2.2}$=13)				
	Motor: 7/16	Sensory: 4/16	Communication: 3/16	Computer: 2/16	

Regarding the suggested VR system, MUVEs were the most frequently offered. However, there was great diversity (which again reflects the significant heterogeneity among the studies) in the VR systems that reached consensus. Various VR systems have been explored in studies with higher-functioning individuals with autism without intellectual disability. Research has inquired diverse skill areas including safety skills (Self et al., 2007), emotional responses and social motivation (Kim et al., 2015), and facial affect recognition (Bekele et al., 2014; Bekele et al., 2012). While these studies suggest potential benefits within their specific targeted domains, sample sizes have typically been small and findings remain preliminary. Pertinent literature highlights both the potential applications of VR technology and the clear need for larger-scale validation studies.

Regarding the VR affordances, as might be somewhat expected, they followed the diversity of the VR systems, with 'Avatars' being the ones with the highest frequency. Avatar-based interventions have shown preliminary promise in small-scale studies. Cheng and Ye (2010) conducted a pilot study with three participants using collaborative virtual environments with avatars, reporting improvements in targeted social competence behaviors. Hopkins et al. (2011) evaluated the FaceSay computer-based program, which used avatars for emotion recognition training and social skills development. While both studies reported positive outcomes within their limited samples, the preliminary nature of this evidence and need for larger-scale validation should again be noted.

Similarly, regarding the VR learning affordances, some diversity was observed, with 'Modeling & simulation' having the highest frequency. Research has explored modeling and simulation approaches for specific skill training with individuals with autism. Smith et al. (2014, 2015) developed virtual reality job interview training (VR-JIT) for young adults, demonstrating improved interview performance in a randomized controlled trial with 26 participants, with follow-up data at six months for 23 participants showing increased likelihood of obtaining competitive positions. While these studies show promise in their specific domains, each addresses distinct skill areas rather than comprehensive social communication competencies.

Regarding the VR task activity/category, the diverse findings continue with 'Social engagement' and 'Real-life representations' receiving the highest frequencies. This is somewhat expected, as studies with Profile-2 populations have frequently targeted specific aspects of social interaction and practical skills. For example, job interview preparation (Smith et al., 2014, 2015) and safety skills training (Self et al., 2007) use real-life representations, while emotional skills training (Lorenzo et al., 2016) incorporates social engagement elements. The diversity in task categories reflects the range of intervention goals targeted with this population.

Lastly, regarding the ISSSs, many of them reached consensus (8/13) with a notable preference for motor and computer skills. This may reflect the more complex virtual environments used in studies with higher-functioning individuals with autism, which often require navigation, menu selection, text input, and other computer-based interactions. The diversity of the VR systems in this set of design guidelines suggests that individuals in this profile can work with different types of VR technology, though they likely require some foundational computer skills. However, the relationship between prerequisite computer skills and VR intervention success remains an area requiring further investigation.

Besides the noted and significant heterogeneity of existing studies, it is noteworthy that most studies provide limited evidence regarding transfer of learned skills to real-world contexts beyond the virtual environment. Also, there is great heterogeneity within the Profile-2 population itself (i.e., individuals with mild ASD without intellectual disability). This suggests that responses to VR interventions may vary considerably based on individual factors. These considerations highlight the need for larger-scale studies with diverse samples and rigorous assessment of skill generalization and long-term maintenance of learned skills in naturalistic settings.

7.4 Design guidelines for Profile-3 (Severe ASD with ID)

Out of the 13 proposed design guidelines (representing 13 VR combinations and their corresponding 16 ISSSs) for individuals with severe ASD and ID, none achieved the acceptable consensus threshold of 75% or higher. Contrary to our initial expectations (based on earlier VR studies that reportedly included lower-functioning participants), we anticipated that at least a few of these guidelines (possibly the fewest among the four profiles) would reach consensus. This complete lack of agreement highlights fundamental gaps in the empirical foundation supporting Profile-3 interventions.

This could be (in part and methodologically) attributed to the fact that experts with identified documented research experience involving severe ASD with ID populations did not participate in the final Delphi round. While this attrition may have contributed to the lack of consensus, it also reflects the fact that even among autism VR experts, direct experience with Profile-3 populations is not common with significant attrition occurring when expertise was of high importance.

Furthermore, literature revealed research design barriers for individuals presenting with Profile-3 characteristics not be included as some studies appeared to require cognitive functioning and capabilities (such as IQ thresholds of >70, verbal communication requirements, and reading comprehension demands). Other barriers that lead to not including individuals with Profile-3 are operating and navigating technology interface designs requiring sustained attention, abstract reasoning, and complex motor coordination which are capabilities often (profoundly) impaired in severe ID populations (Parsons, 2016; Strickland, 1997).

Overall, research appears to tend to include higher-functioning individuals with autism, thus leading to a lack of data and evidence for Profile-3 populations. Therefore, this lack of consensus may reflect expert recognition that current VR technologies embody assumptions fundamentally incompatible with severe cognitive limitations. Current VR approaches require cognitive capabilities (such as sustained attention, cause-effect reasoning, spatial memory, and abstraction) that are reportedly impaired in severe ID. Thus, this could (also) indicate that the VR technologies and intervention approaches are at this time presenting with constraints and possibly are not aligned, sensitive, inclusive and ultimately not compatible (at least not enough) for individuals with severe autism that also present with cognitive limitations (Parsons, 2016).

Table 7.5 provides an overview of the experts' answers for Profile-3. It reveals preference patterns of the participating experts that given the overall circumstances (including the scarcity if not lack of relevant empirical data), should be interpreted with caution. The VR system that was most suggested was the Desktop (7/13). This might be a reflection of accessibility considerations as opposed to documented effectiveness. Desktop systems require fewer motor and spatial demands and can also be considered as easier to use and lower in cost, as opposed to more immersive technologies, making them more applicable for individuals with (severe) ID challenges and limitations.

Regarding the affordances and the activities most frequently suggested for this profile, preferences were noted with regard to the VR affordance of "real-time interaction" (8/13), the VR learning affordance of "modeling & simulation" (11/13), and VR task activity of "gaming" (6/13). However, these selections may not be reasonably applicable for individuals presenting with significant global and cognitive delays such as in cases with severe ID where cognitive skills, abstract thinking and processing, sustained attention and overall comprehension can be (profoundly) impacted. Thus, these preferences could be viewed more as theoretical approaches rather than evidence-based recommendations. They also could be viewed as presenting some contradictions with experts possibly reflecting on views from different than Profile-3 specific populations.

Overall, this is of significance as current literature does not (systematically) look into, identifies, or sets safety protocols for potential adverse effects (e.g., sensory sensitivities and overload, cognitive overload, seizure risks, lack of spatial/time disorientation) of VR use, implementation, and exposure. This lack of safety measures is concerning overall and particularly for individuals with severe ASD and ID who may not be able to communicate (verbally or non-verbally) distress and harm in general (Parsons, 2016). Thus, ethical concerns are raised for implementing interventions and methodologies with no significantly supporting data about vulnerable populations that cannot self-advocate (Beauchamp and Childress, 2013).

The most frequently suggested skill set (ISSS) was motor skills. This presents somewhat of an inconsistency if not contradiction as Desktop VR requires basic controller operation thus minimizing motor demands. Also, similarly to the affordances, pertinent literature does not offer much information about the (motor) skills of the participating individuals (oftentimes it is the communication and cognitive skills that are mentioned). Thus, it is challenging to determine whether motor skills are needed for the effectiveness of VR, as they may be impaired in Profile-3 individuals. Overall, these issues along with the heterogeneity of existing empirical studies, the underreporting of information regarding the participating individuals participants, as well as the design of pertinent virtual environments per se, adds complexity in further examining these parameters and their combinations.

Table 7.5 Overview of the experts' answers for Profile-3; no consensus reached.

	VR combinations ($N_{3.1}$=13)			
VR system	Desktop: 7/13	Semi-immersive: 4/13	Augmented Reality: 2/13	
VR affordances	Real-time interaction: 8/13	Avatars: 5/13		
VR learning affordance	Modeling & simulation: 11/13	Multi-channel communication: 2/13		
VR task activity/category	Gaming: 6/13	Real-life representation: 4/13	Interaction w/ content: 2/13	Social engagement: 1/13
	ISSS: ($N_{3.2}$=16)			
	Motor: 7/16	Sensory: 4/16	Communication: 3/16	Computer: 2/16

Thus, there is little data and evidence in current literature regarding Profile-3 individuals in VR contexts and therefore the effectiveness of VR interventions.

Research documenting significant performance differences between functioning levels (Parsons, Mitchell and Leonard, 2005; Mitchell, Parsons and Leonard, 2007; Parsons, 2016) demonstrates that individuals with lower verbal ability and weaker executive functions show markedly different VR interaction patterns and learning outcomes compared to higher-functioning participants. These documented differences provide empirical basis for concluding that extrapolation from high-functioning research to Profile-3 populations is methodologically inappropriate and potentially misleading, ineffective, and inadvisable.

This challenges virtual environments' veridicality and thus their use as "a bridge to the real world or as a truthful stimulus to prompt and reproduce real world responding" (Parsons, 2016, p.143). Generalizing the veridicality of virtual environments for Profile-3 populations is a fundamental theoretical issue rather than a technical limitation. Generalization from virtual to real-world contexts requires cognitive capabilities (including abstraction, analogical reasoning, context discrimination, and flexible application of learned rules) that can be impaired in (severe) intellectual disability (Detterman, 1993). Virtual environments and their somewhat abstract nature can be a significant barrier for populations whose cognitive profiles are characterized by concrete, context-bound thinking (Parsons, 2016, p.143). This impacts the generalization (or lack thereof) of any acquired skills from the virtual environment to the real world, which is the ultimate target of any intervention approach. Thus, for Profile-3 populations, VR may be an additional abstract layer that increases rather than decreases learning complexity, potentially positioning these interventions as contraindicated rather than just unvalidated.

7.5 Design guidelines for Profile-4 (Severe ASD without ID)

Out of a total of 25 suggested design guidelines (i.e., 25 VR combinations and their respective 35 ISSSs) for individuals with severe ASD and without ID, 23 reached the acceptable consensus level of at least 75%. The two VR combinations that did not reach consensus were:

a) targeting ‘Communication skills’ (#46): Desktop (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category) / ISSS: Communication skills and
b) targeting ‘Behavioral & emotional skills’ (#63): Full immersive (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category) / ISSS: Computer skills.

The two rejected design guidelines show no systematic pattern related to VR system type or skill domain, suggesting they could represent individual expert uncertainty rather than fundamental concerns about these specific combinations. With 92% of the suggested guidelines reaching consensus, analysis focuses on the accepted guidelines while acknowledging their theoretical rather than empirical foundation. Table 7.6 depicts all the design guidelines that reached consensus. It is noteworthy that between Profile-3 (individuals with severe ASD and ID) and Profile-4 (individuals with severe ASD and without ID), none (i.e., 0%) of the suggested guidelines for Profile-3 reached consensus, as opposed to 92% of the proposed guidelines for Profile-4.

The noted contrast between the 92% expert consensus for Profile-4 and no consensus for Profile-3 reveals a critical research gap. While experts confidently suggested design guidelines (again to be viewed as preferences as opposed to rigorous recommendations based on empirical knowledge and evidence) for severe ASD without ID, this confidence appears to be based on theoretical reasoning rather than empirical evidence. Our systematic review of autism VR studies revealed that only a handful of them provided any data potentially applicable to severe ASD without ID populations. Most studies excluded individuals requiring substantial support (e.g., Smith et al., 2014; Didehbani et al., 2016; and Bozgeyikli et al., 2017 targeted "high-functioning" individuals). This exclusion could mean that the expert consensus represents informed extrapolation from dissimilar populations rather than empirical validation for Profile-4 characteristics.

This paradox suggests that preserved cognitive functioning (absence of intellectual disability) possibly enables experts to extrapolate from existing VR research, while the combination of severe autism with intellectual disability (Profile-3) creates uncertainty even among experienced researchers. However, extrapolation from high-functioning populations to severe autism populations (regardless of intellectual functioning) represents a significant methodological leap requiring empirical validation.

We believe that this also highlights the following: a) the (perceived) key role cognitive skills play in the successful and beneficial use of virtual environments for individuals with autism, b) the need for establishing a comprehensive baseline before administering the virtual environment, c) the need for a thorough history and description of the participants' clinical profile (including their present levels of performance/skills and functioning), d) the importance of a user-centered approach and careful consideration of all parameters (technological and human) when designing inclusive and beneficial virtual environments for these groups, and e) the need for empirical, safe, and ethical research in this area and for these populations.

Table 7.6 Design guidelines for Profile-4 (Severe ASD without ID)

		VR combination						
		VR system	**VR affordance**	**VR learning affordance)**	**VR task activity/category)**	**VR Consensus**	**ISSS**	**ISSS Consensus**
Social Skills	**#41**	Desktop	Real-time interaction	Modeling & simulation	Social engagement	87.5%	Communication	75%
							Computer skills	75%
Communication skills	**#42**	Desktop	Real-time interaction	Collaboration & cooperation	Interaction with content	87.5%	Communication skills	-
	#43	Desktop	Real-time interaction	Collaboration & cooperation	Social engagement	87.5%	Communication skills	-
	#44	Desktop	Avatars	Collaboration & cooperation	Interaction with content	75%	Communication skills	-
	#45	Desktop	Avatars	Collaboration & cooperation	Social engagement	75%	Communication skills	-
	#47	Desktop	1st user point of view	Collaboration & cooperation	Social engagement	87.5%	Communication skills	-
Cognitive Skills	**#48**	Desktop	1st user point of view	Modeling & simulation	Gaming	87.5%	Computer skills	-
	#49	Desktop	1st user point of view	Modeling & simulation	Interaction with content	75%	Computer skills	-
Daily living/ functional life skills	**#50**	Full immersive	Real-time interaction	Modeling & simulation	Gaming	75%	Motor skills	-
							Computer skills	-
	#51	Full immersive	Real-time interaction	Modeling & simulation	Interaction with content	87.5%	Motor skills	-
							Computer skills	-
	#52	Full immersive	Real-time interaction	Modeling & simulation	Real-life representation	75%	Motor skills	
							Computer skills	
	#53	Full immersive	Immersion	Modeling & simulation	Gaming	100%	Motor skills	75%
							Computer skills	-

	#54	Full immersive	Immersion	Modeling & simulation	Interaction with content	100%	Motor skills	75%
							Computer skills	-
	#55	Full immersive	Immersion	Modeling & simulation	Real-life representation	87.5%	Motor skills	-
							Computer skills	-
	#56	Full immersive	Presence	Modeling & simulation	Gaming	100%	Motor skills	75%
							Computer skills	-
	#57	Full immersive	Presence	Modeling & simulation	Interaction with content	100%	Motor skills	75%
							Computer skills	-
	#58	Full immersive	Presence	Modeling & simulation	Real-life representation	100%	Motor skills	75%
							Computer skills	-
Sensorimotor skills	**#59**	Full immersive	Real-time interaction	Modeling & simulation	Interaction with content	100%	Motor skills	87.5%
Behavioral & Emotional skills	**#60**	Desktop	Avatars	Collaboration & cooperation	Interaction with content	75%	Computer skills	-
	#61	Desktop	Avatars	Collaboration & cooperation	Social engagement	87.5%	Computer skills	-
	#62	Full immersive	Avatars	Collaboration & cooperation	Interaction with content	75%	Computer skills	-
	#64	MUVEs	Avatars	Collaboration & cooperation	Interaction with content	100%	Computer skills	-
	#65	MUVEs	Avatars	Collaboration & cooperation	Social engagement	87.5%	Computer skills	-

As previously mentioned, due to the heterogeneity of the pertinent studies and the individuals with autism themselves, we review the accepted design guidelines within the profile. Table 7.7 shows an overview of the design guidelines.

Table 7.7 Overview of the experts' answers for Profile-4; 92% consensus reached for the VR combinations (design guidelines).

	VR combinations ($N_{4.1}$=23, $N_{0,4.1}$=25)				
VR system	Full-immersive: 11/23	Desktop: 10/23	MUVEs: 2/23		
VR affordances	Real-time interaction: 7/23	Avatars: 7/23	1st point of view: 3/23	Immersion: 3/23	Presence: 3/23
VR learning affordance	Modeling & simulation: 13/23	Collaboration & cooperation: 10/23			
VR task activity/category	Interaction w/ content: 10/23	Social engagement: 6/23	Gaming: 4/23	Real-life representation: 3/23	
	ISSS: ($N_{4.2}$=8, $N_{0, 4.2}$=35)				
	Motor: 6/8	Communication: 1/8	Computer: 1/8		

As previously mentioned, while experts reached 92% consensus for Profile-4 design guidelines, our comprehensive literature review of autism VR studies revealed an absence of or minimal empirical research specifically targeting individuals with severe ASD without intellectual disability. This consensus therefore could represent expert opinion based on extrapolation from other populations rather than direct empirical validation for Profile-4 characteristics and needs.

Regarding the suggested VR system, the Full-immersive and Desktop VR systems share the highest frequency. However, it is critical to acknowledge that these expert recommendations lack empirical validation specifically for severe ASD without ID populations. Existing autism VR research demonstrates feasibility of both full-immersive and desktop systems; however, this evidence derives predominantly from studies of high-functioning populations (Mesa-Gresa et al., 2018). For example, Kuriakose and Lahiri (2017) investigated anxiety-sensitive adaptation with nine high-functioning participants; and Parsons et al. (2005) examined higher-functioning adolescents. It is noteworthy that early foundational work by Strickland et al. (1996) examined two children with autism using head-mounted display technology, though this case study's extremely small sample (n=2), single-session design, and now-outdated technology limit applicability to current Profile-4 recommendations. Moreover, both participants had IQs in the average or near-average range, meaning even this foundational study did not specifically target severe autism populations. The expert consensus therefore could represent informed extrapolation rather than evidence-based recommendations. Nonetheless, particularly regarding use of HMDs, this continues to be a sensitive issue, as recent studies highlight the sensory sensitivities that individuals with autism often exhibit. This is something that needs careful consideration when using this type of equipment/technology.

About the VR affordances, there was a noteworthy connection between 'Real-time interaction' and 'Avatars'. Real-time interaction has been supported by pertinent literature, as it reinforces a more realistic experience, which is especially meaningful for individuals with autism, as they tend to have a more concrete perception of their environment. Regarding avatars, research shows mixed findings that remain population-dependent. Studies with high-functioning populations demonstrate avatar effectiveness for social skills training (Kandalaft et al., 2013; Didehbani et al., 2016), though these findings may not generalize to severe autism. For severe ASD populations specifically, evidence is sparse and contradictory with these conflicting findings likely reflect the heterogeneity within severe ASD populations and the absence of research systematically examining avatar design parameters for Profile-4 individuals.

Regarding the VR learning affordances, the two that reached consensus and had similar high frequencies were ‘Collaboration & cooperation’ and ‘Modeling & simulation’, with the former having a slightly higher frequency than the latter. Literature has mentions of virtual environments that are based on ‘Collaboration and cooperation’ and some with ‘Modeling & simulation. However, existing implementations of collaboration-based and simulation-based VR learning predominantly target high-functioning populations (e.g., Stichter et al., 2014; Ke & Im, 2013). The theoretical rationale for these approaches, that preserved cognitive functioning enables complex virtual interactions, may support their proposed application to Profile-4, yet empirical validation remains absent. This evidence gap prevents confident recommendations about optimal learning affordances for severe ASD without ID. Nonetheless, we propose that this aspect of the design guidelines be maintained and further explored.

With regard to the VR task activity/category, the one that gathered the highest frequency was ‘Interaction w/ content.’ Some studies capitalize on this versatile VR task activity, with some mentions and applications also for individuals with severe autism. These studies’ findings report benefits while pointing out the potential of these virtual environments and the need for further research. Also, it is noteworthy that ‘Interaction w/ content’ was one of the least frequent VR tasks for Profile-3, although both profiles for individuals with severe autism (ASD) involved the same VR tasks, but in different frequencies.

Lastly, regarding the ISSSs, only a small number of them reached consensus (8/35), with motor skills being the most frequently agreed-upon area. These skills are significantly underreported in the literature, and their inclusion in this set of design guidelines will help highlight their significance. It is noteworthy that motor skills achieved highest ISSS consensus (6/8 guidelines) despite the recommended VR systems (Full-immersive and Desktop) typically requiring minimal motor engagement unless controllers are employed. This apparent contradiction may reflect expert recognition that: a) motor skill development represents a significant need area for Profile-4 populations, b) VR controller use could provide structured motor practice opportunities, and c) immersive systems with motion tracking may eventually support motor interventions. However, the mismatch between recommended systems and targeted skills underlines the theoretical rather than empirical basis of these guidelines, as actual motor intervention protocols for Profile-4 populations using these VR systems are not developed or tested.

A critical limitation pertains to whether skills acquired in VR environments transfer to real-world behavior (the fundamental goal of any intervention). It is noteworthy that most autism VR research has not directly assessed generalization beyond the virtual environment (Parsons, 2016). Even studies demonstrating improvements within VR contexts rarely include follow-up assessment of real-world behavioral changes. For Profile-4 individuals specifically, no studies have systematically examined generalization of VR-learned skills to everyday functional contexts. This represents a crucial research gap, as individuals with severe ASD may experience particular difficulty generalizing learned skills across contexts, potentially limiting VR intervention effectiveness regardless of system design. Future research should prioritize generalization assessment through direct observation of real-world behavior rather than relying on performance within VR environments or standardized assessments administered in clinical settings.

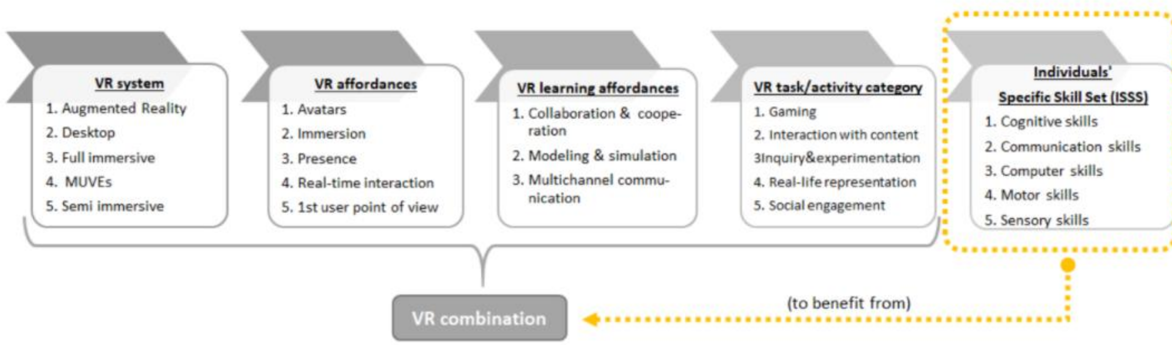
Lastly, the Profile-4 findings also reveal an important paradox, i.e. high expert consensus (92%) achieved despite systematic absence of empirical research for this population. This pattern, contrasting with Profile-3's lack of consensus (i.e., 0%), suggests experts could extrapolate from existing literature when intellectual disability is absent, even though such extrapolation across autism severity levels represents a substantial methodological leap. Thus, Profile-4 guidelines should also be interpreted as expert-generated hypotheses requiring empirical validation rather than evidence-based recommendations. This lack of evidence is particularly concerning given that individuals with severe ASD without ID may benefit substantially from VR's structured, predictable environments yet remain completely not studied. The combination of high expert confidence and lack of research absence highlights Profile-4 individuals for future empirical investigation, addressing both a scientific gap and an ethical obligation to these underserved individuals.

7.6 Conclusions

In a three-tier approach to our conclusions, we propose the following:

7.6.1 Tier-1: the framework for the design guidelines

Firstly, we propose the following framework as a model for design guidelines for virtual environments for individuals with autism:



7.6.2 Tier-2: the general design guidelines per profile

As the second tier of our approach, we propose the following general design guidelines per clinical autism profile:

	VR system	VR affordance	VR learning affordance	VR task/activity	ISSS*
Profile-1	Full-immersive	Real-time interaction	Collaboration & cooperation:	Social engagement	Communication
Profile-2	MUVEs	Avatars	Modeling & simulation	Social engagement	Motor
Profile-3	Desktop	Real-time interaction	Modeling & simulation	Gaming	Motor
Profile-4	Full-immersive	Real-time interaction	Modeling & simulation	Interaction w/ content	Motor

*Will need to be viewed in correlation with at least one of the VR combination components to be taken into consideration.

7.6.3 Tier-3: the specific design guidelines per profile and targeted skills

Lastly, the third tier of the design guidelines comprises the explicit design guidelines, as described in detail in Tables 7.1, 7.3, and 7.6.

In conclusion, regarding the use of virtual environments for individuals with autism, it seems that this technology has the potential to offer treatment benefits. Nonetheless, VR's veridicality does not warrant the transfer and generalization of (any possible) gained benefits/skills from the digital to the real world. The heterogeneity of the relevant studies and the autism population play a key role in this matter. However, and moving forward, the following can make a positive impact to realistically bridge this gap and enhance positive outcomes: interdisciplinary and user-centered approach for the development of the virtual environments; digital knowledge and understanding of this technological mean's affordances and thus capabilities; deep knowledge and understanding of the autism disorder; acknowledging and taking into consideration of the individuality of each case/participant, and addressing the heterogeneity and inconsistencies regarding the manner of conducting and reporting relevant studies. Ultimately, considering virtual reality and its relevant applications within the framework and umbrella of Assistive Technology (A.T.) could redefine researchers' perspectives and lead to a more inclusive and accessible approach.

7.7 Limitations

As with every research, we note the following limitations for this study. The first two limitations are the primary limitations of our research, and the remaining three are secondary. We discuss each limitation, offering criticism about the pros and cons of each case, and provide arguments for why we chose to pursue each of these routes scientifically and realistically.

7.7.1 Broad study scope

The first and one of the main limitations of this study concerns its broad scope regarding autism and VR. The search for a set of design guidelines was undertaken without any further specifications about the characteristics of the targeted autism population (e.g., age, diagnosis, clinical profile) and/or the targeted virtual reality technologies (e.g., VR types/systems, affordances, targeted skills). This broad approach led to receiving a large number of diverse qualitative data that was challenging to process and categorize. Furthermore, any attempts to compare, corroborate (or not), and correlate our results with those of other studies were similarly challenging. This was also due to two factors, namely the significant heterogeneity of relevant studies and the lack of established design guidelines. Thus, due to concerns that there might not be adequate data regarding our work/findings, adopting a broader approach gave us flexibility in addressing this issue.

Overall, we acknowledge that targeting specific group(s) of the autism population and VR technologies in the beginning and/or later stages (rounds) of the study would have helped with our data being more manageable. This was apparent after the completion of the first round of the Delphi study. As already mentioned, the large number and diversity of the collected qualitative data were challenging, and so was their processing, etc. We contemplated narrowing the study's scope at that point; however, we did not proceed with it. The reason was the concern of selection bias in the case that a more specific direction was followed. Thus, although narrowing the scope of this study at any of its stages would have made our data more manageable, we believe that the followed broad approach allowed for a more comprehensive, flexible, and unbiased view of the matter under study.

Furthermore, using the e-Delphi technique, which is based on the classical Delphi method, a broader initial approach was necessary. Thus, the first round of the study utilizes open-ended questions to encourage participating experts to share their views and generate (new) ideas freely. Nonetheless, to provide some direction, we opted for a set of open-ended and somewhat targeted questions (based on relevant literature) instead of a single broad question (e.g., "Which design guidelines for virtual environments would you suggest for individuals with autism?").

7.7.2 Lack of empirical testing

Another significant limitation of the study is that the proposed design guidelines were not empirically tested. Although this would be preferable and possibly provide additional insight, understanding, and validity to the suggested guidelines, it would have been quite ambitious, likely unrealistic, and perhaps not appropriate. There are three main reasons for this. Firstly, the proposed design guidelines from this study are numerous and organized in a manner that targets specific clinical profiles and VR technologies. Thus, any corresponding empirical studies would need to meet specific criteria. This would significantly contribute to the quality of this type of empirical study. However, there would be certain challenges that would require initiating and following through with several research actions/steps, such as finding individuals with autism who share a similar clinical profile. This is a challenge in itself, as small sample sizes are well-documented for studies with individuals with autism, as they represent a low-incidence and diverse disability group.

Furthermore, specialized VR equipment would be required, along with the design of relevant VR environments and intervention activities. All these would be exceedingly laborious, time-consuming, and costly to do at this point in our research. This also highlights the importance of adopting an interdisciplinary approach and securing funding when designing virtual environments for individuals with autism. Our study, as well as other recent studies, support the need for researchers from different disciplines to be involved in this type of study. Thus, completing this research with the conclusion of the Delphi study is a reasonable choice, with its empirical aspect being the next logical step, if not a series of steps/studies.

7.7.3 Other limitations

Other secondary limitations that often pertain to Delphi studies include concerns about attrition, pressures of conformity, and the expertise of the panel. Regarding attrition, there was considerable attrition between the study rounds, although within the limits often reported in the literature. It is noted that numerous precautions were taken in every round to minimize this overall. For example, we followed suggested strategies in the Delphi-critiquing literature for encouraging experts' participation, such as sending personalized emails, etc. Noted attrition could be due to the administered questionnaires for Rounds 2 and 3 being quite elaborate and lengthy, despite a series of actions taken to ensure their optimal design, comprehensive context, and user-friendly administration/completion. These actions included incorporating guidelines for questionnaire development, having more than one draft of a questionnaire as needed, conducting extensive pilot and mini-pilot testing, and providing specific and clear directions for completing each questionnaire. Nonetheless, we acknowledge that completing the questionnaires was laborious and time-consuming; we appreciate the time and effort the participating experts invested in completing them.

Regarding the pressures of conformity, the Delphi technique is a well-documented limitation. Although this is an overall concern, we believe that in our study there were limited conformity pressures for the following reasons: experts' anonymity was maintained throughout the study, the study was conducted remotely, experts were exposed to the views of their fellow panelists in a controlled and as unbiased as possible manner via the feedback/summary the received after each round, and each expert had a strong research/scholar background which allowed them to critically appraise different opinions and make an informed decision/change of their views. Also, incorporating pertinent suggestions from the literature and having what we believe to be rigorous pilot and mini-pilot testing, we feel that participating experts were able to freely and unbiasedly express and change their views while generating new ideas and opinions (individually and collectively).

Another possible limitation of our study is that the expert panel consisted exclusively of researchers and scholars from the field of autism and VR research. Thus, the views of other stakeholders such as individuals with autism (who are the intended users of the virtual environments), their parents, teachers, and service providers, were excluded. Literature has documented the importance of incorporating the stakeholders and especially users' opinions in the design of such virtual applications and activities. We believe that involving all stakeholders in the design process is imperative for developing successful and beneficial virtual reality interventions for individuals with autism. Nonetheless, and for the needs of our study, we argue that having an expert panel of knowledgeable and experienced researchers was appropriate. They appear to be better qualified and to have the theoretical and empirical background to share, evaluate, and shape new and previous information that would lead to the development of a comprehensive framework for the design guidelines. Although we believe that it will be invaluable to include stakeholders' views in the next steps of this study, i.e. empirical testing of the suggested design guidelines, we feel that tried to highlight the importance of a more user-centered approach by organizing the guidelines per clinical profile (including the comorbidity aspect) and by introducing the ISSS which takes into consideration the till now underreported and somewhat under considered unique needs, strengths and weaknesses of the individuals with autism so that they are benefited from the design of the pertinent virtual environments.

7.8 Future work

We have identified and propose the following areas for future work:

- Empirical testing (small or large scale) of each design guideline that reached consensus.
- Investigation (qualitative and/or quantitative studies) of the design guidelines that did not reach consensus, and especially the ones targeted in Profile-3 (severe ASD with ID).
- Further investigation of the suggested design guidelines with an emphasis on the ISSS involved in each design guideline. The latter will support the development of inclusive and individualized virtual environments that benefit users and facilitate the transfer of skills from virtual contexts to the real world. This area remains understudied and is frequently cited as a limitation and suggested area for future research in the literature.
- Further investigation of the affordances that can assist in the generalization of skills is necessary, as generalization cannot be assumed and requires specific and targeted design to be achieved.
- Development of a research protocol for empirical studies in virtual reality and autism. This could be in the form of a questionnaire or checklist and could include the following areas among others: i) clinical information about the participants, ii) baseline, iii) de-briefing/interviews/questionnaires to receive involved stakeholders' feedback, opinions/views, and suggestions, iv) research design, and v) design of the virtual environment(s)[14].

[14] In more detail: i) clinical information about the participants (e.g., age, gender, grade, type/name of diagnosis, comorbid disorders, authority/institution issuing the diagnosis), ii) baseline (e.g., skills as mentioned in the ISSs and overall, needs, strengths, weaknesses, computer/technology experience and use including AAC, services received and test scores from developmental batteries for different areas of functioning); iii) de-briefing/interviews/questionnaires to receive involved stakeholders' feedback, opinions/views and suggestions, iiiv) research design (e.g., empirical/qualitative study, pre-test/post-test, pilot testing, comparison groups, follow-ups), and v) design of the virtual environment(s) (e.g., VR type, system, technology, VR affordances, VR learning affordances, VR tasks, design guidelines/theories/principles, targeted skills, prior training/experience of users with VR software/hardware, conditions of administration, presence and training of facilitators, benefits and adverse/harmful effects, limitations, potential and generalizations (or not) of reported findings).

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Mikropoulos T.A. (2016) University of Ioannina, Greece Educational Virtual Environments: Turning Affordances into Pedagogical Features through Reasoning. Presentation in: UQAM, Summer School in Cognitive Sciences 2016 (June 20th to July 1st, 2016)

- *Abstract:* http://summer16.isc.uqam.ca/page/programme.php?lang_id=2#Mikropoulos (accessed on 1/15/2021)
- *Presentation:* https://uqam.ca.panopto.com/Panopto/Pages/Viewer.aspx?id=948ffb67-cb0a-46c0-a66d-6b91594f5922

Mikropoulos, T.A. (2018). The Learning Affordances of Virtual Reality (Δυνατότητες μάθησης της εικονικής πρακτικότητας) – Presentation. VR@GR. Stegi Onassis, November 24-25, 2018.

APPENDIX A

A.1.1 The diagnostic criteria for autism from DSM-I to DSM-V

Source: McDougle, 2016, p. 7

Table A.1 The diagnostic criteria for autism from DSM-I to DSM-V (*Source:* McDougle, 2016, p. 7)
DSM-I (1952) and DSM-II (1968)
Autism was not officially recognized. A limited number of diagnoses existed for childhood-onset disorders.
DSM-III (1980)
Infantile autism and residual autism were included in a new "class" of disorder (Pervasive Developmental Disorders (PDD)) along with a "late-onset" form of autism (childhood-onset PDD) and "subthreshold" PDD (atypical PDD). Advantages included use of a multiaxial approach and a research criteria approach to definition. A major disadvantage was the lack of a developmental orientation.
DSM-III-R (1987)
Autistic disorder and a new term for "subthreshold" PDD (Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS)) were put forth. An advantage included a

greater developmental orientation (polythetic criteria) but likely an overly broad diagnostic concept.
DSM-IV (1994)
In addition to autistic disorder, other conditions (Asperger's disorder, Rett's disorder, and childhood disintegrative disorder) were recognized along with PDD-NOS. Advantages for autism included convergence with the ICD-10 definition and good balance of sensitivity and specificity over IQ range as well as flexible polythetic definitions. Disadvantages included controversy regarding inclusion of "new" disorders, particularly Asperger's disorder. With the convergence of DSM-IV and ICD-10, research comparability was enhanced and resulted in an explosion of research papers.
DSM-IV-TR (text revision) (2004)
There were no changes in criteria (although there was a minor change in the description of PDD-NOS to make it clear that social difficulties have to be present). Major changes were made in the text description of Asperger's disorder.
DSM-5 (2013)

Autism spectrum disorder and the new concept of social communication disorder (the latter being a communication disorder) were put forth. Autism spectrum disorder replaces autistic disorder as well as the PDD term. Although use of "spectrum" implies broader definition, the actual definition is probably much more focused on "classic" autism, with many more able cases likely facing loss of label. As a result, a "grandfathering" rule was adopted (for cases with an older diagnosis but not for new cases). The subthreshold concept was dropped, and reliance was placed on data from diagnostic instruments rather than field trials. Adoption of a grandfathering rule effectively keeps both the old and the new system in current use, likely complicating research—particularly epidemiological and longitudinal studies.

A.1.2 Autism Spectrum Disorder

Source: Diagnostic and statistical manual of mental disorders, 5th ed. (American Psychiatric Association, 2013, p. 50-51).

"Diagnostic Criteria 299.00 (F84.0)

1. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by all of the following, currently or by history (examples are illustrative, not exhaustive; see text):
    1. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.
    2. Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in

understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.

3. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.

   Specify current severity:

   - Severity is based on social communication impairments and restricted, repetitive patterns of behavior (see Table).

2. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text):
   1. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).
   2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat same food every day).
   3. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g., strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interests).
   4. Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

      Specify current severity:

      - Severity is based on social communication impairments and restricted, repetitive patterns of behavior (see Table).

3. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities or may be masked by learned strategies in later life).
4. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.
5. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level.

Note: Individuals with a well-established DSM-IV diagnosis of autistic disorder, Asperger's disorder, or pervasive developmental disorder not otherwise specified should be given the diagnosis of autism spectrum disorder. Individuals who have marked deficits in social communication, but whose symptoms do not otherwise meet criteria for autism spectrum disorder, should be evaluated for social (pragmatic) communication disorder.

Specify if:

- With or without accompanying intellectual impairment
- With or without accompanying language impairment
- Associated with a known medical or genetic condition or environmental factor (Coding note: Use additional code to identify the associated medical or genetic condition.)
- Associated with another neurodevelopmental, mental, or behavioral disorder (Coding note: Use additional code[s] to identify the associated neurodevelopmental, mental, or behavioral disorder[s].)

With catatonia (refer to the criteria for catatonia associated with another mental disorder, pp. 119–120, for definition) (Coding note: Use additional code 293.89 [F06.1] catatonia associated with autism spectrum disorder to indicate the presence of the comorbid catatonia.)

APPENDIX B

Author	Title	Year	Journal	Database(s)
Strickland, D.	A Virtual Reality Application with Autistic Children	1996	Grandin	SCOPUS MIT Press
Strickland, D., Marcus, L. M., Mesibov, G. B., & Hogan, K.	Brief report: Two case studies using virtual reality as a learning tool for autistic children	1996	Journal of Autism and DevelopmentalDisorders	EBSCOhost ERIC SCOPUS PubMed SpringerLink
Rutten, A., Cobb, S., Neale, H., Kerr, S., Leonard, A., Parsons, S., & Mitchell, P.	The AS interactive project: single-user and collaborative virtual environments for people with high-functioning autistic spectrum disorders	2003	The Journal of Visualization and Computer Animation	Wiley Interscience
Lányi, C. S., & Tilinger, Á.	Multimedia and Virtual Reality in the Rehabilitation of Autistic Children	2004	International Conference on Computers for Handicapped Persons	SpringerLink
Parsons, S., Mitchell, P., & Leonard, A.	The Use and Understanding of Virtual Environments by Adolescents with Autistic Spectrum Disorders	2004	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Moore, D., Cheng, Y., McGrath, P., & Powell, N. J.	Collaborative Virtual Environment Technology for People With Autism	2005	Focus on Autism and Other Developmental Disabilities	SCOPUS ACM Digital Library EBSCOhost ERIC IEEE ProQuest SAGE Journals
Parsons, S., Mitchell, P., & Leonard, A.	Do adolescents with autistic spectrum disorders adhere to social conventions in virtual environments?	2005	Autism	SCOPUS ERIC PubMed SAGE Journals
Jung, K. E., Lee, H. J., Lee, Y. S., Cheong, S. S., Choi, M. Y., Suh, D. S., ... & Lee, J. H. - AMA style: Ko-Eun Jung, Hyun-Jhin Lee, Young-Sik Lee, Seong-Shim Cheong, Min-Young Choi, Dong-Soo Suh	The Application of a Sensory Integration Treatment Based on Virtual Reality-Tangible Interaction for Children with Autistic Spectrum Disorder	2006	PsychNology Journal	SCOPUS
Mitchell, P., Parsons, S., & Leonard, A.	Using Virtual Environments for Teaching Social Understanding to 6 Adolescents with Autistic Spectrum Disorders	2006	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Parsons, S., Leonard, A., & Mitchell, P.	Virtual environments for social skills training: comments from two adolescents with autistic spectrum disorder	2006	Computers & Education	ACM Digital Library Elsevier ERIC ScienceDirect SCOPUS
Self, T., Scudder, R. R., Weheba, G., & Crumrine, D.	A virtual approach to teaching safety skills to children with autism spectrum disorder	2007	Topics in Language disorders	SCOPUS ERIC

Strickland, D. C., McAllister, D., Coles, C. D., & Osborne, S.	An evolution of virtual reality training designs for children with autism and fetal alcohol spectrum disorders	2007	Top Lang Disord	SCOPUS ERIC PubMed
Bente, G., Eschenburg, F., & Krämer, N. C.	Virtual Gaze. A Pilot Study on the Effects of Computer Simulated Gaze in Avatar-Based Conversations	2007	International Conference on Virtual Reality	SpringerLink
Herrera, G., Alcantud, F., Jordan, R., Blanquer, A., Labajo, G., & De Pablo, C.	Development of symbolic play through the use of virtual reality tools in children with autistic spectrum disorders	2008	Autism	SCOPUS ERIC PubMed SAGE Journals
Josman, N., Ben-Chaim, H. M., Friedrich, S., & Weiss, P. L.	Effectiveness of virtual reality for teaching street-crossing skills to children and adolescents with autism.	2008	Int J Disabil Hum Dev	SCOPUS
Tartaro, A., & Cassell, J.	Playing with Virtual Peers. Bootstrapping Contingent Discourse in Children with Autism.	2008	N/A	ACM Digital Library
Austin, D. W., Abbott, J. A. M., & Carbis, C.	The use of virtual reality hypnosis with two cases of autism spectrum disorder: a feasibility study	2008	Contemporary Hypnosis	Wiley Interscience
Grynszpan, O., Nadel, J., Carbonell, N., Simonin, J., Constant, J., Le Barillier, F., ... & Courgeon, M.	A new virtual environment paradigm for high functioning autism intended to help attentional disengagement in a social context bridging the gap between relevance theory and executive dysfunction	2009	2009 Virtual Rehabilitation International Conference	SCOPUS EBSCOhost ProQuest
Welch, K. C., Lahiri, U., Liu, C., Weller, R., Sarkar, N., & Warren, Z.	An Affect-Sensitive Social Interaction Paradigm Utilizing Virtual Reality Environments for Autism Intervention	2009	International conference on human-computer interaction	SCOPUS SpringerLink ACM Digital Library
Wang, M., & Reid, D.	The virtual reality-cognitive rehabilitation (VR-CR) approach for children with autism	2009	Journal of CyberTherapy & Rehabilitation	SCOPUS
Konstantinidis, E. I., Hitoglou-Antoniadou, M., Luneski, A., Bamidis, P. D., & Nikolaidou, M. M.	Using affective avatars and rich multimedia content for education of children with autism.	2009	Proceedings of the 2nd international conference on pervasive technologies related to assistive environments	SCOPUS ACM Digital Library
Milne, M., Luerssen, M. H., Lewis, T. W., Leibbrandt, R. E., & Powers, D. M.	Development of a Virtual Agent Based Social Tutor for Children with Autism Spectrum Disorders	2010	2010 International joint conference on neural networks (IJCNN)	SCOPUS IEEE
Cheng, Y., Chiang, H. C., Ye, J., & Cheng, L. H.	Enhancing empathy instruction using a collaborative virtual learning environment for children with autistic spectrum conditions	2010	Computers & Education	SCOPUS Elsevier ScienceDirect
Cheng, Y., & Ye, J.	Exploring the social competence of students with autism spectrum conditions in a collaborative virtual learning environment – The pilot study	2010	Computers & Education	SCOPUS ACM Digital Library ERIC Elsevier ScienceDirect
Schwartz, C., Bente, G., Gawronski, A., Schilbach, L., & Vogeley, K.	Responses to Nonverbal Behaviour of Dynamic Virtual Characters in High-Functioning Autism	2010	Journal of Autism and Developmental Disorders	ERIC SCOPUS EBSCOhost ProQuest PubMed SpringerLink
Wallace, S., Parsons, S., Westbury, A., White, K., White, K., & Bailey, A. - AMA style: Simon Wallace, Sarah Parsons,	Sense of presence and atypical social judgments in immersive virtual environments	2010	Autism	SCOPUS ERIC PubMed SAGE Journals

Alice Westbury, Katie White, Kathy White, Anthony Bailey				
Hopkins, I. M., Gower, M. W., Perez, T. A., Smith, D. S., Amthor, F. R., Wimsatt, F. C., & Biasini, F. J.	Avatar Assistant: Improving Social Skills in Students with an ASD Through a Computer-Based Intervention	2011	Journal of Autism and Developmental Disorders	EBSCOhost ERIC PubMed SpringerLink ProQuest SCOPUS
Lahiri, U., Warren, Z., & Sarkar, N.	Design of a Gaze-Sensitive Virtual Social Interactive System for Children With Autism	2011	IEEE Transactions on Neural Systems and Rehabilitation Engineering	SCOPUS IEEE PubMed
Lahiri, U., Trewyn, A., Warren, Z., & Sarkar, N.	Dynamic Eye gaze and its Potential in Virtual Reality Based Applications for Children with Autism Spectrum Disorders	2011	Autism - Open Access	PubMed
Lahiri, U., Warren, Z., & Sarkar, N.	Dynamic gaze measurement with adaptive response technology in Virtual Reality based social communication for autism	2011	International Conference on Virtual Rehabilitation	SCOPUS IEEE
Rajendran, G., Law, A. S., Logie, R. H., Van Der Meulen, M., Fraser, D., & Corley, M.	Investigating Multitasking in High-Functioning Adolescents with Autism Spectrum Disorders Using the Virtual Errands Task	2011	Journal of Autism and Developmental Disorders	EBSCOhost ERIC ProQuest PubMed SpringerLink
Alcorn, A., Pain, H., Rajendran, G., Smith, T., Lemon, O., Porayska-Pomsta, K., ... & Bernardini, S. - AMA style: Alyssa Alcorn, Helen Pain, Gnanathusharan Rajendran, Tim Smith, Oliver Lemon, Kaska Porayska-Pomsta, Mary Ellen Foster, Katerina Avramides, Christopher Frauenberger, and Sara Bernardini	Social Communication between Virtual Characters and Children with Autism	2011	international conference on artificial intelligence in education	SCOPUS SpringerLink ACM Digital Library
Trepagnier, C. Y., Olsen, D. E., Boteler, L., & Bell, C. A.	Virtual Conversation Partner for Adults with Autism	2011	Cyberpsychology, Behavior, and Social Networking	SCOPUS EBSCOhost Mary Ann Liebert PubMed
Weilun, L., Elara, M. R., & Garcia, E. M. A.	Virtual Game Approach For Rehabilitation In Autistic Children	2011	2011 8th International Conference on Information, Communications & Signal Processing	SCOPUS IEEE
Chia, N. K. H., & Li, J.	Design of a Generic Questionnaire for Reflective Evaluation of a Virtual Reality-Based Intervention Using Virtual Dolphins for Children with Autism	2012	International Journal of Special Education	SCOPUS EBSCOhost ERIC
Lahiri, U., Bekele, E., Dohrmann, E., Warren, Z., & Sarkar, N.	Design of a Virtual Reality Based Adaptive Response Technology for Children With Autism	2012	IEEE Transactions on Neural Systems and Rehabilitation Engineering	ACM Digital Library IEEE PubMed SpringerLink SCOPUS
Lima, D., & Castro, T.	Music Spectrum: A Music Immersion Virtual Environment for Children with Autism	2012	Procedia Computer Science	IEEE Elsevier ScienceDirect SCOPUS

Greffou, S., Bertone, A., Hahler, E. M., Hanssens, J. M., Mottron, L., & Faubert, J.	Postural Hypo-Reactivity in Autism is Contingent on Development and Visual Environment: A Fully Immersive Virtual Reality Study	2012	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed, SpringerLink
Cheng, Y., & Huang, R.	Using virtual reality environment to improve joint attention associated with pervasive developmental disorder	2012	Research in Developmental Disabilities	SCOPUS Elsevier ERIC PubMed
Schmidt, M., & Laffey, J.	Visualizing Behavioral Data from a 3D Virtual Learning Environment: A Preliminary Study	2012	2012 45th Hawaii International Conference on System Sciences	SCOPUS
Cai, Y., Chia, N. K., Thalmann, D., Kee, N. K., Zheng, J., & Thalmann, N. M.	Design and Development of a Virtual Dolphinarium for Children With Autism	2013	IEEE Transactions on Neural Systems and Rehabilitation Engineering	SCOPUS IEEE PubMed
Bernardini, S., Porayska-Pomsta, K., & Sampath, H.	Designing an Intelligent Virtual Agent for Social Communication in Autism	2013	Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment	ACM Digital Library
Alcorn, A. M., Pain, H., & Good, J.	Discrepancies in a virtual learning environment: something "Worth communicating about" for young children with ASC?	2013	Proceedings of the 12th International Conference on Interaction Design and Children	SCOPUS ACM Digital Library
Bamasak, O., Al-Tayari, H., Al-Harbi, S., Al-Semairi, G., & Abu-Hnaidi, M.	Improving Autistic Children's Social Skills Using Virtual Reality	2013	Design, User Experience, and Usability. Health, Learning, Playing, Cultural, and Cross-Cultural User ExperienceLecture Notes in Computer Science	SpringerLink ACM Digital Library
Lorenzo, G., Pomares, J., & Lledó, A.	Inclusion of immersive virtual learning environments and visual control systems to .support the learning of students with Asperger syndrome	2013	Computers & Education	SCOPUS Elsevier ERIC ScienceDirect
Chia, N. K. H., Cai, Y., Kee, N. K. N., Thalmann, N., Yang, B., Zheng, J., & Thalmann, D.	Learning Activity System Design for Autistic Children Using Virtual Pink Dolphins	2013	3D Immersive and Interactive Learning	SCOPUS SpringerLink
Fornasari, L., Chittaro, L., Ieronutti, L., Cottini, L., Dassi, S., Cremaschi, S., ... & Brambilla, P. - AMA syle: Livia Fornasari, Luca Chittaro, Lucio Ieronutti, Lucio Cottini, Sebastiano Dassi, Silvana Cremaschi, Massimo Molteni, Franco Fabbro, Paolo Brambilla	Navigation and exploration of an urban virtual environment by children with autism spectrum disorder compared to children with typical development	2013	Research in Autism Spectrum Disorders	SCOPUS Elsevier ScienceDirect
Jarrold, W., Mundy, P., Gwaltney, M., Bailenson, J., Hatt, N., McIntyre, N., ... & Swain, L. - AMA style: William Jarrold, Peter Mundy, Mary Gwaltney, Jeremy Bailenson, Naomi Hatt, Nancy McIntyre, Kwanguk Kim, Marjorie Solomon, Stephanie Novotny, Lindsay Swain	Social Attention in a Virtual Public Speaking Task in Higher Functioning Children With Autism	2013	Autism Research	SCOPUS EBSCOhost Wiley Interscience PubMed

Bekele, E., Zheng, Z., Swanson, A., Crittendon, J., Warren, Z., & Sarkar, N.	Understanding How Adolescents with Autism Respond to Facial Expressions in Virtual Reality Environments	2013	IEEE Transactions on Visualization and Computer Graphics	SCOPUS IEEE PubMed ACM Digital Library
Wang, M., & Reid, D.	Using the Virtual Reality-Cognitive Rehabilitation Approach to Improve Contextual Processing in Children with Autism	2013	The Scientific World Journal	SCOPUS PubMed
Bouck, E. C., Satsangi, R., Doughty, T. T., & Courtney, W. T.	Virtual and Concrete Manipulatives: A Comparison of Approaches for Solving Mathematics Problems for Students with Autism Spectrum Disorder	2013	Journal of Autism and Developmental Disorders	ERIC PubMed SpringerLink SCOPUS ProQuest
Kandalaft, M. R., Didehbani, N., Krawczyk, D. C., Allen, T. T., & Chapman, S. B.	Virtual Reality Social Cognition Training for Young Adults with High-Functioning Autism	2013	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
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Ke, F., & Im, T.	Virtual-Reality-Based Social Interaction Training for Children with High-Functioning Autism	2013	The Journal of Educational Research	EBSCOhost Taylor & Francis SCOPUS ERIC
Millen, L., Cobb, S., Patel, H., & Glover, T.	A collaborative virtual environment for conducting design sessions with students with autism spectrum disorder	2014	Int J Child Health Hum Dev	
Christiansen, L. G., Brooks, A. L., Brooks, E. P., & Rosenørn, T.	A Virtual Dressing Room for People with Asperger's Syndrome	2014	International Conference on Universal Access in Human-Computer Interaction	SCOPUS SpringerLink
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Kee, N. K. N.	Application of Universal Design for Learning (Udl1) and Living (Udl2) in Virtual Dolphin-Assisted Intervention (Vdai) for Children with Autism	2014	The Journal of the International Association of Special Education	EBSCOhost ERIC
Carter, E. J., Williams, D. L., Hodgins, J. K., & Lehman, J. F.	Are Children with Autism More Responsive to Animated Characters? A Study of Interactions with Humans and Human-Controlled Avatars	2014	Journal of Autism and Developmental Disorders	EBSCOhost SpringerLink SCOPUS ERIC ProQuest
Bekele, E., Crittendon, J., Zheng, Z., Swanson, A., Weitlauf, A., Warren, Z., & Sarkar, N.	Assessing the Utility of a Virtual Environment for Enhancing Facial Affect Recognition in Adolescents with Autism	2014	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Schwartz, C., Dratsch, T., Vogeley, K., & Bente, G.	Brief Report: Impression Formation in High-Functioning Autism: Role of Nonverbal Behavior and Stereotype Activating Information	2014	Journal of Autism and Developmental Disorders	ERIC

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Wang, X., Desalvo, N., Gao, Z., Zhao, X., Lerman, D. C., Gnawali, O., & Shi, W.	Eye contact conditioning in autistic children using virtual reality technology	2014	Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering	SpringerLink
Matsentidou, S., & Poullis, C.	Immersive Visualizations in a VR Cave Environment for the Training and Enhancement of Social Skills for Children with Autism	2014	2014 International Conference on Computer Vision Theory and Applications (VISAPP)	SCOPUS IEEE
Stichter, J. P., Laffey, J., Galyen, K., & Herzog, M.	iSocial: Delivering the Social Competence Intervention for Adolescents (SCI-A) in a 3D Virtual Learning Environment for Youth with High Functioning Autism	2014	Journal of Autism and Developmental Disorders	ERIC PubMed SCOPUS SpringerLink ProQuest
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Maskey, M., Lowry, J., Rodgers, J., McConachie, H., & Parr, J. R.	Reducing Specific Phobia/Fear in Young People with Autism Spectrum Disorders (ASDs) through a Virtual Reality Environment Intervention	2014	PLoS ONE	EBSCOhost PubMed SCOPUS ProQuest
Georgescu, A. L., Kuzmanovic, B., Roth, D., Bente, G., & Vogeley, K.	The Use of Virtual Characters to Assess and Train Non-Verbal Communication in High-Functioning Autism	2014	Frontiers in Human Neuroscience	SCOPUS PubMed
Smith, M. J., Ginger, E. J., Wright, K., Wright, M. A., Taylor, J. L., Humm, L. B., ... & Fleming, M. F. - AMA style: Matthew J. Smith, Emily J. Ginger, Katherine Wright, Michael A. Wright, Julie Lounds Taylor, Laura Boteler Humm, Dale E. Olsen, Morris D. Bell, Michael F. Fleming	Virtual Reality Job Interview Training in Adults with Autism Spectrum Disorder	2014	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Lahiri, U., Bekele, E., Dohrmann, E., Warren, Z., & Sarkar, N.	A Physiologically Informed Virtual Reality Based Social Communication System for Individuals with Autism	2015	Journal of Autism and Developmental Disorders	SCOPUS ERIC ProQuest PubMed SpringerLink
Kim, K., Rosenthal, M. Z., Gwaltney, M., Jarrold, W., Hatt, N., McIntyre, N., ... & Mundy, P.	A Virtual Joy-Stick Study of Emotional Responses and Social Motivation in Children with Autism Spectrum Disorder	2015	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Wade, J., Bian, D., Fan, J., Zhang, L., Swanson, A., Sarkar, M., ... & Sarkar, N.	A Virtual Reality Driving Environment for Training Safe Gaze Patterns: Application in Individuals with ASD	2015	International Conference on Universal Access in Human-Computer Interaction	SCOPUS SpringerLink

Smith, M. J., Fleming, M. F., Wright, M. A., Losh, M., Humm, L. B., Olsen, D., & Bell, M. D.	Brief Report: Vocational Outcomes for Young Adults with Autism Spectrum Disorders at Six Months After Virtual Reality Job Interview Training	2015	Journal of Autism and Developmental Disorders	ERIC PubMed SCOPUS SpringerLink ProQuest
Zhang, L., Wade, J., Swanson, A., Weitlauf, A., Warren, Z., & Sarkar, N.	Cognitive state measurement from eye gaze analysis in an intelligent virtual reality driving system for autism intervention	2015	2015 International Conference on Affective Computing and Intelligent Interaction (ACII)	SCOPUS IEEE
Mantziou, O., Vrellis, I., & Mikropoulos, T. A.	Do Children in the Spectrum of Autism Interact with Real-time Emotionally Expressive Human Controlled Avatars?	2015	Procedia Computer Science	SCOPUS Elsevier ScienceDirect
Ke, F., Im, T., Xue, X., Xu, X., Kim, N., & Lee, S.	Experience of Adult Facilitators in a Virtual-Reality-Based Social Interaction Program for Children With Autism	2015	The Journal of Special Education	SCOPUS ERIC SAGE Journals
Mei, C., Mason, L., & Quarles, J.	How 3D Virtual Humans Built by Adolescents with ASD Affect Their 3D Interactions	2015	Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility - ASSETS '15	SCOPUS ACM Digital Library
Parsons, S.	Learning to work together: Designing a multi-user virtual reality game for social collaboration and perspective-taking for children with autism	2015	International Journal of Child-Computer Interaction	Elsevier ScienceDirect SCOPUS
Ringland, K. E., Wolf, C. T., Dombrowski, L., & Hayes, G. R.	Making" Safe" Community-Centered Practices in a Virtual World Dedicated to Children with Autism	2015	Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing	ACM Digital Library
Zhang, L., Wade, J., Bian, D., Fan, J., Swanson, A., Weitlauf, A., ... & Sarkar, N. - AMA style: Zhang, Joshua Wade, Dayi Bian, Jing Fan, Amy Swanson, Amy Weitlauf, Zachary Warren, Nilanjan Sarkar	Multimodal Fusion for Cognitive Load Measurement in an Adaptive Virtual Reality Driving Task for Autism Intervention	2015	Universal Access in Human-Computer Interaction. Access to Learning, Health and Well-BeingLecture Notes in Computer Science	SCOPUS SpringerLink
Saiano, M., Pellegrino, L., Casadio, M., Summa, S., Garbarino, E., Rossi, V., ... & Sanguineti, V. - AMA style: Mario Saiano, Laura Pellegrino, Maura Casadio, Susanna Summa, Eleonora Garbarino, Valentina Rossi, Daniela Dall'Agata, Vittorio Sanguineti	Natural interfaces and virtual environments for the acquisition of street crossing and path following skills in adults with Autism Spectrum Disorders: a feasibility study	2015	Journal of NeuroEngineering and Rehabilitation	SCOPUS EBSCOhost PubMed SpringerLink
Bian, D., Wade, J., Swanson, A., Warren, Z., & Sarkar, N.	Physiology-based affect recognition during driving in virtual environment for autism intervention	2015	Proceedings of the 2nd International Conference on Physiological Computing Systems	SCOPUS
Perhakaran, G., Yusof, A. M., Rusli, M. E., Yusoff, M. Z. M., Mahidin, E. M. M., Mahalil, I., & Zainuddin, A. R. R. - AMA style: Gamini Perhakaran, Azmi Mohd Yusof, Mohd Ezanee Rusli, Mohd Zaliman Mohd Yusoff, Eze Manzura Mohd Mahidin,	SnoezelenCAVE: Virtual Reality CAVE Snoezelen Framework for Autism Spectrum Disorders	2015	International Visual Informatics Conference	SCOPUS SpringerLink

Imran Mahalil, and Ahmad Redza Razieff Zainuddin				
Sarkar, A., Wade, J., & Warren, Z.	Understanding and Improving Collaborative Skills Among Individuals with ASD in a Distributed Virtual Environment	2015	Universal Access in Human-Computer Interaction. Access to Learning, Health and Well-BeingLecture Notes in Computer Science	SCOPUS SpringerLink
Kuriakose, S., & Lahiri, U.	Understanding the Psycho-Physiological Implications of Interaction With a Virtual Reality-Based System in Adolescents With Autism: A Feasibility Study	2015	IEEE Transactions on Neural Systems and Rehabilitation Engineering	SCOPUS IEEE PubMed
Cheng, Y., Huang, C. L., & Yang, C. S.	Using a 3D Immersive Virtual Environment System to Enhance Social Understanding and Social Skills for Children With Autism Spectrum Disorders	2015	Focus on Autism and Other Developmental Disabilities	SCOPUS SAGE Journals
Ramachandiran, C. R., Jomhari, N., Thiyagaraja, S., & Maria, M.	Virtual Reality Based Behavioral Learning For Autistic Children	2015	Electronic Journal of E-Learning	EBSCOhost, ERIC
Stendal, K., & Balandin, S.	Virtual worlds for people with autism spectrum disorder: a case study in Second Life	2015	Disability and Rehabilitation	PubMed SCOPUS Taylor & Francis
Wade, J., Zhang, L., Bian, D., Fan, J., Swanson, A., Weitlauf, A., ... & Sarkar, N.	A Gaze-Contingent Adaptive Virtual Reality Driving Environment for Intervention in Individuals with Autism Spectrum Disorders	2016	ACM Transactions on Interactive Intelligent Systems	ACM Digital Library
Zhao, H., Swanson, A., Weitlauf, A., Warren, Z., & Sarkar, N.	A Novel Collaborative Virtual Reality Game for Children with ASD to Foster Social Interaction	2016	Universal Access in Human-Computer Interaction. Users and Context DiversityLecture Notes in Computer Science	SCOPUS SpringerLink
Parsons, T. D., & Carlew, A. R.	Bimodal Virtual Reality Stroop for Assessing Distractor Inhibition in Autism Spectrum Disorders	2016	Journal of Autism and Developmental Disorders	SCOPUS EBSCOhost ERIC ProQuest PubMed SpringerLink
Newbutt, N., Sung, C., Kuo, H. J., Leahy, M. J., Lin, C. C., & Tong, B.	Brief Report: A Pilot Study of the Use of a Virtual Reality Headset in Autism Populations	2016	Journal of Autism and Developmental Disorders	ERIC PubMed SpringerLink SCOPUS
Schmidt, M., & Beck, D.	Computational thinking and social skills in Virtuoso: An immersive, digital game-based learning environment for youth with autism spectrum disorder	2016	International Conference on Immersive Learning	SpringerLink SCOPUS
Lorenzo, G., Lledó, A., Pomares, J., & Roig, R.	Design and application of an immersive virtual reality system to enhance emotional skills for children with autism spectrum disorders	2016	Computers & Education	SCOPUS ACM Digital Library Elsevier ScienceDirect
Kuriakose, S., & Lahiri, U.	Design of a Physiology-Sensitive VR-Based Social Communication Platform for Children With Autism	2016	IEEE Transactions on Neural Systems and Rehabilitation Engineering	SCOPUS IEEE PubMed
Wang, X., Laffey, J., Xing, W., Ma, Y., & Stichter, J.	Exploring embodied social presence of youth with autism in 3D collaborative virtual learning environment: A case study	2016	Computers in Human Behavior	SCOPUS Elsevier ScienceDirect ACM Digital Library
Carter, E. J., Hyde, J., Williams, D. L., & Hodgins, J. K.	Investigating the Influence of Avatar Facial Characteristics on the Social Behaviors of Children with Autism	2016	Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems	SCOPUS ACM Digital Library

Miller, H. L., & Bugnariu, N. L.	Level of Immersion in Virtual Environments Impacts the Ability to Assess and Teach Social Skills in Autism Spectrum Disorder	2016	Cyberpsychology, Behavior, and Social Networking	SCOPUS EBSCOhost Mary Ann Liebert PubMed
Bozgeyikli, E., Raij, A., Katkoori, S., & Dubey, R.	Locomotion in Virtual Reality for Individuals with Autism Spectrum Disorder	2016	Proceedings of the 2016 Symposium on Spatial User Interaction	SCOPUS ACM Digital Library
Bekele, E., Wade, J., Bian, D., Fan, J., Swanson, A., Warren, Z., & Sarkar, N.	Multimodal adaptive social interaction in virtual environment (MASI-VR) for children with Autism spectrum disorders (ASD)	2016		SCOPUS IEEE
Bian, D., Wade, J., Warren, Z., & Sarkar, N.	Online Engagement Detection and Task Adaptation in a Virtual Reality Based Driving Simulator for Autism Intervention	2016	Universal Access in Human-Computer Interaction. Users and Context DiversityLecture Notes in Computer Science	SpringerLink SCOPUS
White, S. W., Richey, J. A., Gracanin, D., Coffman, M., Elias, R., LaConte, S., & Ollendick, T. H.	Psychosocial and computer-assisted intervention for college students with autism spectrum disorder: Preliminary support for feasibility.	2016	Education and training in autism and developmental disabilities	ERIC
Forbes, P. A., Pan, X., & Hamilton, A. F. D. C.	Reduced Mimicry to Virtual Reality Avatars in Autism Spectrum Disorder	2016	Journal of Autism and Developmental Disorders	SCOPUS ERIC PubMed SpringerLink
Newbutt, N., Sung, C., Kuo, H. J., & Leahy, M. J.	The potential of virtual reality technologies to support people with an autism condition: A case study of acceptance, presence and negative effects	2016	Annual Review of Cybertherapy and Telemedicine	SCOPUS
Beach, J., & Wendt, J.	Using Virtual Reality to Help Students with Social Interaction Skills	2016	The Journal of the International Association of Special Education	EBSCOhost
Good, J., Parsons, S., Yuill, N., & Brosnan, M.	Virtual reality and robots for autism: moving beyond the screen	2016	Journal of Assistive Technologies	SCOPUS Emerald
Ke, F., & Lee, S.	Virtual reality based collaborative design by children with high-functioning autism: design-based flexibility, identity, and norm construction	2016	Interactive Learning Environments	Taylor & Francis SCOPUS
Ip, H. H., Wong, S. W., Chan, D. F., Byrne, J., Li, C., Yuan, V. S., ... & Wong, J. Y. - AMA style: Horace H.S. Ip,(&), Simpson W.L. Wong, Dorothy F.Y. Chan, Julia Byrne, Chen Li,(&), Vanessa S.N. Yuan, Kate S.Y. Lau, and Joe Y.W. Wong	Virtual Reality Enabled Training for Social Adaptation in Inclusive Education Settings for School-Aged Children with Autism Spectrum Disorder (ASD)	2016	International Conference on Blended Learning	SCOPUS SpringerLink
Bozgeyikli, E., Bozgeyikli, L., Raij, A., Katkoori, S., Alqasemi, R., & Dubey, R.	Virtual Reality Interaction Techniques for Individuals with Autism Spectrum Disorder: Design Considerations and Preliminary Results	2016	International Conference on Human-Computer Interaction	SCOPUS ACM Digital Library SpringerLink
Didehbani, N., Allen, T., Kandalaft, M., Krawczyk, D., & Chapman, S.	Virtual Reality Social Cognition Training for children with high functioning autism	2016	Computers in Human Behavior	SCOPUS ACM Digital Library Elsevier ScienceDirect
Herring, P., Kear, K., Sheehy, K., & Jones, R.	A virtual tutor for children with autism	2017	Journal of Enabling Technologies	SCOPUS Emerald
Yang, Y. D., Allen, T., Abdullahi, S. M., Pelphrey, K. A., Volkmar, F. R., & Chapman, S. B.	Brain responses to biological motion predict treatment outcome in young adults with	2017	Behaviour Research and Therapy	SCOPUS Elsevier

	autism receiving Virtual Reality Social Cognition Training: Preliminary findings			PubMed ScienceDirect
Cox, D. J., Brown, T., Ross, V., Moncrief, M., Schmitt, R., Gaffney, G., & Reeve, R.	Can Youth with Autism Spectrum Disorder Use Virtual Reality Driving Simulation Training to Evaluate and Improve Driving Performance? An Exploratory Study	2017	Journal of Autism and Developmental Disorders	SCOPUS PubMed SpringerLink
Zhang, L., Wade, J., Bian, D., Fan, J., Swanson, A., Weitlauf, A., ... & Sarkar, N.	Cognitive Load Measurement in a Virtual Reality-Based Driving System for Autism Intervention	2017	IEEE Transactions on Affective Computing	IEEE PubMed
Adjorlu, A., Høeg, E. R., Mangano, L., & Serafin, S.	Daily Living Skills Training in Virtual Reality to Help Children with Autism Spectrum Disorder in a Real Shopping Scenario	2017	2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct)	IEEE
Cai, Y., Chiew, R., Nay, Z. T., Indhumathi, C., & Huang, L.	Design and development of VR learning environments for children with ASD	2017	Interactive Learning Environments	SCOPUS Taylor & Francis
Halabi, O., El-Seoud, S. A., Alja'am, J. M., Alpona, H., Al-Hemadi, M., & Al-Hassan, D.	Design of Immersive Virtual Reality System to Improve Communication Skills in Individuals with Autism	2017	International Journal of Emerging Technologies in Learning (iJET)	SCOPUS EBSCOhost
Fan, J., Wade, J. W., Key, A. P., Warren, Z. E., & Sarkar, N.	EEG-Based Affect and Workload Recognition in a Virtual Driving Environment for ASD Intervention	2017	IEEE Transactions on Biomedical Engineering	IEEE PubMed
Nojavanasghari, B., Hughes, C. E., & Morency, L. P.	Exceptionally social: Design of an avatar-mediated interactive system for promoting social skills in children with autism	2017	Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems	ACM Digital Library SCOPUS
Wang, X., Laffey, J., Xing, W., Galyen, K., & Stichter, J.	Fostering verbal and non-verbal social interactions in a 3D collaborative virtual learning environment: a case study of youth with Autism Spectrum Disorders learning social competence in iSocial	2017	Educational Technology Research and Development	SCOPUS SpringerLink
Babu, P. R. K., Oza, P., & Lahiri, U.	Gaze-Sensitive Virtual Reality Based Social Communication Platform for Individuals with Autism	2017	IEEE Transactions on Affective Computing	IEEE
Halabi, O., El-Seoud, S. A., Alja'am, J. M., Alpona, H., & Al-Hassan, D.	Immersive Virtual Reality in Improving Communication Skills in Children with Autism	2017	International Journal of Interactive Mobile Technologies (iJIM)	EBSCOhost
Chevalier, P., Martin, J. C., Isableu, B., Bazile, C., & Tapus, A.	Impact of sensory preferences of individuals with autism on the recognition of emotions expressed by two robots, an avatar, and a human	2017	Autonomous Robots	SCOPUS SpringerLink
Root, J. R., Browder, D. M., Saunders, A. F., & Lo, Y. Y.	Schema-Based Instruction With Concrete and Virtual Manipulatives to Teach Problem Solving to Students With Autism	2017	Remedial and Special Education	SCOPUS ERIC SAGE Journals
Wallace, S., Parsons, S., & Bailey, A.	Self-reported sense of presence and responses to social stimuli by adolescents with autism spectrum disorder in a collaborative virtual reality environment	2017	Journal of Intellectual & Developmental Disability	SCOPUS Taylor & Francis
Lamash, L., Klinger, E., & Josman, N.	Using a virtual supermarket to promote independent functioning among adolescents with Autism Spectrum Disorder	2017	2017 International Conference on Virtual Rehabilitation (ICVR)	IEEE
Bozgeyikli, L., Bozgeyikli, E., Raij, A., Alqasemi, R., Katkoori, S., & Dubey, R.	Vocational Rehabilitation of Individuals with Autism Spectrum Disorder with Virtual Reality	2017	ACM Transactions on Accessible Computing	SCOPUS ACM Digital Library
Ip, H. H., Wong, S. W., Chan, D. F., Byrne, J., Li, C., Yuan, V. S., ... & Wong, J. Y. - AMA style:	Enhance emotional and social adaptation skills for children with autism spectrum disorder: A virtual reality enabled approach	2018	Computers & Education	Elsevier ScienceDirect

Horace H.S. Ip, Simpson W.L. Wong, Dorothy F.Y. Chan, Julia Byrne, Chen Li, Vanessa S.N. Yuan, Kate S.Y. Lau, Joe Y.W. Wong				
Burke, S. L., Bresnahan, T., Li, T., Epnere, K., Rizzo, A., Partin, M., ... & Trimmer, M. - AMA style: Shanna L. Burke, Tammy Bresnahan, Tan Li, Katrina Epnere, Albert Rizzo, Mary Partin, Robert M. Ahlness, Matthew Trimmer	Using Virtual Interactive Training Agents (ViTA) with Adults with Autism and Other Developmental Disabilities	2018	Journal of Autism and Developmental Disorders	PubMed SpringerLink
Bian, D., Wade, J., Swanson, A., Weitlauf, A., Warren, Z., & Sarkar, N.	Design of a physiology-based adaptive virtual reality driving platform for individuals with ASD	2019	ACM Transactions on Accessible Computing (TACCESS)	SCOPUS EBSCOhost
Maskey, M., Rodgers, J., Ingham, B., Freeston, M., Evans, G., Labus, M., & Parr, J. R.	Using Virtual Reality Environments to Augment Cognitive Behavioral Therapy for Fears and Phobias in Autistic Adults	2019	Autism Adulthood	SCOPUS SpringerLink
Maskey, Morag, Rodgers, J., Grahame, V., Glod, M., Honey, E., Kinnear, J., Labus, M., Milne, J., Minos, D., McConachie, H., & Parr, J. R.	A Randomised Controlled Feasibility Trial of Immersive Virtual Reality Treatment with Cognitive Behaviour Therapy for Specific Phobias in Young People with Autism Spectrum Disorder	2019	Journal of Autism and Developmental Disorders	Elsevier ScienceDirect
Maskey, M., McConachie, H., Rodgers, J., Grahame, V., Maxwell, J., Tavernor, L., & Parr, J. R.	An intervention for fears and phobias in young people with autism spectrum disorders using flat screen computer-delivered virtual reality and cognitive behaviour therapy.	2019	Research in Autism Spectrum Disorders	SCOPUS EBSCOhost
Rosenfield, S.N., Lamkin, K., Re, J., Day, K., Boyd, L., & Linstead, E.	A virtual reality system for practicing conversation skills for children with autism.	2019	Multimodal Technologies and Interaction	PubMed SpringerLink
Rojo, D., Mayor, J., Rueda, J. J. G., & Raya, L.	A virtual reality training application for adults with Asperger's syndrome	2019	IEEE Computer graphics and applications	IEEE
Grynszpan, O., Bouteiller, J., Grynszpan, S., Le Barillier, F., Martin, J. C., & Nadel, J.	Altered sense of gaze leading in autism.	2019	Research in Autism Spectrum Disorders	Elsevier ScienceDirect
Herrero, J. F., & Lorenzo, G.	An immersive virtual reality educational intervention on people with autism spectrum disorders (ASD) for the development of communication skills and problem solving.	2019	Education and Information Technologies	SCOPUS PubMed SpringerLink
Smith, M. J., Pinto, R. M., Dawalt, L., Smith, J. D., Sherwood, K., Miles, R., ... & Steacy, C.	Using community-engaged methods to adapt virtual reality job-interview training for transition-age youth on the autism spectrum	2020	Research in Autism Spectrum Disorders	PubMed SpringerLink
Ke, F., Moon, J., & Sokolikj, Z.	Virtual reality–based social skills training for children with autism spectrum disorder.	2020	Journal of Special Education Technology	SCOPUS SpringerLink
McCleery, J. P., Zitter, A., Solórzano, R., Turnacioglu, S., Miller, J. S., Ravindran, V., & Parish-Morris, J.	Safety and feasibility of an immersive virtual reality intervention program for teaching police interaction skills to adolescents and adults with autism.	2020	Autism Research	SCOPUS EBSCOhost
De Luca, R., Leonardi, Portaro, Maria Le Cause, Carmela De Domenico, Colucci, Federica	Innovative use of virtual reality in autism spectrum disorder: A case-study.	2021	Applied Neuropsychology: Child	PubMed SpringerLink

Pranio, Bramanti P., & Calabrò. R.S.				
Schmidt, M., Newbutt, N., Schmidt, C., & Glaser, N	A process-model for minimizing adverse effects when using head mounted display-based virtual reality for individuals with autism.	2021	Frontiers in Virtual Reality	SCOPUS SpringerLink
Glaser, N., Schmidt, M., Schmidt, C., Palmer, H., & Beck, D.	The centrality of interdisciplinarity for overcoming design and development constraints of a multi-user virtual reality intervention for adults with autism: a design case	2021	Intersections Across Disciplines	PubMed SpringerLink
Schmidt, M., & Glaser, N.	Investigating the usability and learner experience of a virtual reality adaptive skills intervention for adults with autism spectrum disorder.	2021	Educational Technology Research and Development	Elsevier ScienceDirect

APPENDIX C

University of Ioannina
Department of Primary Education & Educational Approaches to Virtual Reality Technologies - earthLAB

e-Delphi Study

Invitation and Information

E-DELPHI STUDY INVITATION

Dear _______________,

We would like to invite you to take part in an international online Delphi study and share your expert opinion on the topic of *"Design Guidelines for Virtual Environments (VEs) for individuals with Autism Spectrum Disorders (ASD)."*

The aim of this study is to develop a framework and propose design guidelines for VEs to support and benefit individuals with ASD. The study is being undertaken by Ms. Katerina Kalyvioti, as part of her PhD at the University of Ioannina, Greece, and under the supervision of Professor and Dean of the School of Education Dr. Tassos A. Mikropoulos.

We are looking into assembling a multidisciplinary panel of experts with distinguished participants from all around the world to provide their input on this topic. As an established professional in your field, we value your opinion and views and hope you contribute to this panel. Your, and other participants' input, will be systematically synthesized, sending you feedback for each round and until an informed panel consensus is achieved (we anticipate a total of three rounds by the end of July 2017).

Please take a few minutes to review the additional information we are including regarding this study in the "e-Delphi Study Information" section below (such as what is an e-Delphi study, confidentiality, being acknowledged for your participation etc.), and please do not hesitate to contact us if you have any questions and/or need anything else.

We hope you consider your participation and accept this invitation. You can consent simply by submitting your answers for the first online survey/questionnaire (please see the separately emailed survey invitation). Thank you and we look forward hearing from you!

Best regards,

Katerina Kalyvioti

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E-DELPHI STUDY INFORMATION

Dear _______________,

You have been invited to participate in an online Delphi consensus study. Your participation, although optional, is greatly valuable and appreciated. We encourage you to consider providing your input and the impact your views can have in the research field of Virtual Reality (VR) and Autism Spectrum Disorders (ASDs). Please take a few minutes to read the information below in regards to this study and let us know if you have any questions and/or need anything else. Thank you for your time and we look forward to you joining us as one of our distinguished panel experts!

e-Delphi study

The Delphi study (or method or technique) seeks to obtain an informed consensus among a panel of experts by systematically collecting and combining their views through a series of rounds of surveys/questionnaires. Experts' participation is voluntary, anonymous and their answers remain confidential throughout the study. After the completion of each round, and until consensus is achieved, participants receive feedback that reflects the information gathered during the pertinent round. Several variations and different types of the Delphi study have been developed depending the researched topic. For the needs of our study, the e-Delphi variation was used. This type of Delphi study follows the process of the classical Delphi, however the surveys/questionnaires, answers/input, feedback, and overall participation of the experts is done electronically (i.e., via email and/or online surveys). We have selected and used the university's "PEGASUS" webmail provider for our email communication (for further information please refer to: http://noc.uoi.gr) and the online survey tool SurveyMonkey® for the development of our surveys/questionnaires and the use of other features of the website such as reminders etc. (for further information please refer to http://SurveyMonkey.com)

Purpose of the study

The role and potential of virtual reality technologies for individuals with Autism Spectrum Disorders (ASD) has been, and still is, explored for almost two decades now. It is a field that continues to show growth as the learning opportunities that virtual environments offer as well as the increasing population of individuals with ASD (and their needs) are of particular interest. The design of virtual environments, suitable and beneficial for the multi-dimensional and dynamic profile of individuals with ASD, has been a great challenge. There are only a few studies that identify/recommend some guidelines, but overall what is emphasized is the lack and need for the development of general guidelines. The purpose of this study is to develop a framework and propose design guidelines for Virtual Environments that will support and benefit individuals with ASD through a consensus process of an expert panel.

Invitation

We are reaching out to you as we would like to assembly a multidisciplinary panel of qualified experts from all around the world to provide their input on the topic of "Virtual Reality (VR) and Autism Spectrum Disorders (ASD). As an established professional in your field, we value your opinion and views and hope you consider contributing to this panel. We specifically would like to ask your views and opinion for the development of design guidelines for Virtual Environments that will benefit and successfully meet the needs of individuals with Autism Spectrum Disorders. If you choose to accept this invitation you will be asked to access, fill in, and submit online surveys/questionnaires (we anticipate approximately three rounds of surveys/questionnaires by the end of July 2017). Also, we understand that you have a very busy schedule, thus all efforts have been made for this process to be as efficient and functional as possible for you (i.e., pilot studies; pre-tests; user-friendly software; iOS, Windows and Android compatibility, etc.).

Study's outline and participation

It is estimated that this will be a three round study with a projected date for its completion the end of July 2017. Each round will be open for 10 calendar days and a kind email reminder will be sent to you approximately 2-3 days before the due date of each round. On a side note, please know that because of filters/firewalls, email reminders sent via SurveyMonkey® could be blocked and/or sent to your "Spam" folder - so please be aware of each round's due date! After the completion of each round, the collected responses will be processed and you will receive feedback as soon as possible. At the same time, you will also be sent the following round's online survey/questionnaire and the aforementioned steps will be repeated until a panel consensus is reached and/or three rounds are completed. In regards to your participation, please also consider that you will need an electronic device (e.g., computer, laptop, and tablet) and internet to be able to access the online surveys/questionnaires as well as communicate with the researchers.

Consent

Your participation in this study is completely voluntary and you can withdraw at any time and round you wish to do so. Please keep in mind that participating in all rounds is recommended as it ensures the study's reliability; however, withdrawing will not affect you in anyway. If you choose to consent, all you need to do is access, fill in and submit the completed online form with the first round's survey/questionnaire. This way you consent to your participation for the entire study and the pertinent estimated three rounds. You do not need to consent again nor complete, sign and return a form regarding this matter in any part of this study. In the occasion you wish to withdraw, simply do not submit the online survey/questionnaire of the pertinent round by its due date, and you will not receive the following round's survey/questionnaire.

Confidentiality

All your responses are confidential and no personal information will be requested throughout this study. Our communication will be private and individually made via email. Only we will have knowledge and be able to trace pertinent emails if and as needed, so that we better assist you as well as facilitate the collection of the survey's responses. This also includes survey emails, such as invitations, reminders, and thank-you emails, sent to you via SurveyMonkey® (please refer to http://SurveyMonkey.com for the website's privacy policy, security statement, etc.). In case you wish for your survey responses not to be traced back to you at any time, then you can contact us (preferably within 24 hours after receiving the online invitation of each round), and a link for the survey will be emailed to you. Please complete the survey once and by using your preferred online option (i.e., survey's email invitation or link). Also, direct quotes from answers to open-ended questions and comments, could possibly be used as part of the study's surveys/questionnaires, publications and the PhD dissertation. However, this will be done anonymously and your identity will not be revealed (unless you notify us otherwise). Moreover, please know that if you decide at any time to withdraw from the study, the answers and data you have overall submitted up to that time will be included and used in the study.

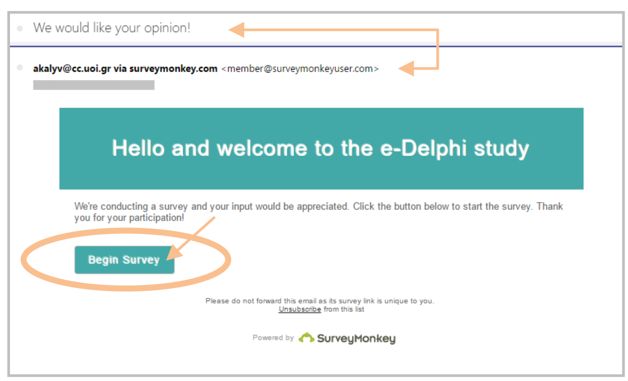
Data protection

For our personal electronic communications, we use our assigned university email addresses and the university's webmail services. The latter is currently running under the 128bit "PEGASUS" encrypted internet server. According to the university's "Network Operation Center (NOC)", this type of connection is the most secure and state of the art connection, that makes it almost impossible for a breach of (personal) information (please refer to NOC's webpage for further information: http://noc.uoi.gr). Also and as already mentioned, we used the online survey tool SurveyMonkey® for this study's needs. Please refer to the company's website (http://SurveyMonkey.com) for a more detailed description of its Security Statement, Privacy Policy, Data Collection and Protection, etc. Please note that hard and electronic copies of the survey's data will be kept by the researchers and remain stored to the SurveyMonkey® website as needed; only the researchers will have access to the aforementioned collected and saved data.

Researchers and Research ethics
This study is conducted by Ms. Katerina Kalyvioti, as part of her PhD at the University of Ioannina, and under the supervision of Professor and Dean of the School of Education Dr. Tassos A. Mikropoulos. The study abides by the ethical requirements of the "Research Ethics Committee" of the University of Ioannina, Greece. For any questions please contact the researchers and/or Professor Andreas Fotopoulos, Chair of the Research Ethics Committee & Vice-Rector, at afotop@uoi.gr.

Acknowledgement
We would like to show you our appreciation for your valuable time and contribution to our study by acknowledging your participation in the study's publications and the PhD dissertation. If you would like to give us that opportunity, please let us know by answering accordingly the pertinent question that will be included only in the study's last round. We would be happy to acknowledge any participation you had to this study as well as make changes to your pertinent response (i.e., to be or not acknowledged), simply by emailing us your request no later than August 10, 2017. Also, please note that by selecting to acknowledge your participation you understand that you willingly reveal your identity in terms of contributing to this study.

Getting started
Following the email with these information, you will also receive separately (approximately within the next 1-2 hours) an email invitation to the survey via SurveyMonkey®. Please note that according to the website "It typically takes 15 min for recipients to receive a message after it's sent, but it can sometimes take an hour. This is to comply with spam regulations […]" We kindly ask you to also check your "Spam" folder, and in the event you do not overall receive the email invitation, to please let us know; we will try to resolve this as soon as possible. Once you receive the invitation e-mail, you will see in the "From" section the "akalyv@cc.uoi.gr" ("akalyv@cc.uoi.gr via surveymonkey.com") email address with the "Subject: We would like your opinion!" If you choose to participate (which we hope you will!) please access the first survey/questionnaire by clicking the "Begin Survey" icon as seen in the screenshot picture. You will then be directed to the online survey/questionnaire. We would also like to bring to your attention



that by accessing, completing and/or submitting the study's survey/questionnaire, you become aware of the first round's content (due by June 8th, 2017) and, as previously mentioned, you consent to your overall participation.

Thank you again for your time and please let us know if you have any questions and/or need anything else.

Kind regards,

Katerina Kalyvioti

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Tassos A. Mikropoulos

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Director of Educational Approaches
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Hello and welcome
to the e-Delphi study

We greatly appreciate your time, help and input!

Here are some information before getting started.

e-Delphi study information

- We encourage you to review the study's information shared in our emails.

Questions?

- We are here for you! Do not hesitate to contact us
at "*akalyv@cc.uoi.gr*" and "*amikrop@uoi.gr*" if you have any questions and/or need anything else.

Study's content and consent:

- Please know that by submitting this form you consent to your participation in this study.

- You become aware of this round's content by accessing this form in any manner. Abbreviations:

- VR: Virtual Reality, ASD: Autism Spectrum Disorders

Thank you
for your participation!

* 1. What is your educational background?
(Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)

- ○ Computer Science/Engineering
- ○ Psychology
- ○ Educational Technology
- ○ Education/Pedagogics
- ○ Physics/Math
- ○ Special Education
- ○ Medicine
- ○ Language Arts/Linguistics/Literature
- ○ Other (please specify)

* 2. What is your current professional position?
(Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)

- ◯ Professor (Full, Associate, Assistant, Lecturer, etc.)
- ◯ Psychologist
- ◯ Researcher (Institute)
- ◯ Medical doctor
- ◯ Computer programmer/engineer
- ◯ Other (please specify)

* 3. Where is your current professional position?
(Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)

- ◯ University
- ◯ Hospital/Clinic
- ◯ Research Institute
- ◯ School/School District
- ◯ Other (please specify)

* 4. In which country is your current professional position located?
(Please select the best answer. Select 'Other' if your preferred answer is not listed or wish to combine multiple [listed or not] answers.)

- Brazil (BR)
- Canada (CA)
- France (FR)
- Germany (DE)
- Greece (GR)
- Hungary (HU)
- India (IN)
- Israel (IL)
- Italy (IT)
- Japan (JP)
- Mexico (MX)
- Norway (NO)
- Polland (PL)
- Portugal (PT)
- Singapore (SG)
- Spain (ES)
- Taiwan (TW)
- United Kingdom (UK)
- United States (US)
- Other (please specify)

* 5. How many years of experience do you have with VR, ASD, and VR & ASD?
(Please select the best answer for each of the three columns.)

	< 5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	> 20 yrs
VR					
ASD					
VR & ASD					

* 6. In your opinion, which VR features/characteristics can be used to benefit individuals with ASD? Please name and/or provide a brief description of them in a hierarchically manner starting with the one you consider the most important.

* 7. In your opinion, which skills and functions would be beneficial to target in VR for individuals with ASD? Please name and/or provide a brief description of them in a hierarchically manner starting with the one you consider the most important.

* 8. In your opinion, which activities/tasks would you design in VR, and for which skills and functions, to benefit individuals with ASD? Please provide a brief description of the activities/tasks for the corresponding skills and functions.

* 9. In your opinion, which characteristics and skills should an individual with ASD have in order to receive the most benefit from VR? Please name and/or provide a brief description of these characteristics and skills in a hierarchically manner starting with the one you consider the most important.

10. Overall, is there anything else you would like to add?

e-Delphi Study: Summary of Round-1

In the study's first round questionnaire and in regards to the VR systems experts would use to design tasks/activities for individuals with ASD, the following VR systems were mentioned: 1. Desktop (desktop or laptop based), 2. Full immersive (HMDs), 3. Semi immersive (3D stereo glasses), 4. MUVEs or Virtual Worlds, and 5. Augmented Reality. Panel experts also highlighted both VR's affordances and learning affordances in regards to those (unique) features/characteristics that would be beneficial to use when designing tasks/activities in VR for individuals with ASD. More specifically the following VR affordances were pointed out: 1. Real time interaction, 2. Immersion, 3. Presence, 4. Users' representation through avatars, and 5. First-person user point of view. Respectively the VR learning affordances that were mentioned included: 1. Free navigation, 2. Creation, 3. Modeling and simulation, 4. Multichannel communication, and 5. Content presentation and/or delivery. In regards to the skills/functions that would be beneficial to target in VR for individuals with ASD, the following 6 skills/functions were overall shared: 1. Social skills, 2. Communication skills, 3. Cognitive skills, 4. Daily living/functional life skills (safety skills, transportation skills, vocational skills, functional academic), 5. Sensorimotor skills, and 6. Behavioral and emotional skills. Regarding the design of tasks/activities for the aforementioned skills, the following five task/activity categories were noted: 1. Games and gamification, 2. Inquiry and experimentation, 3. Interaction with content, 4. Social engagement, and 5. Real life routines/representations. Also, and in regards to the skills/characteristics individuals with ASD could demonstrate in order to receive the most benefit from VR, the following were pointed out: 1. Cognitive skills, 2. Communication skills, 3. Academic skills, 4. Motor skills, 5. Sensory skills, and 6. Computer interest/skills.

Experts also provided additional information regarding the overall field of VR for individuals with ASD. More specifically, 4 experts noted the following: a) creation of virtual worlds for communication with others, b) individuals with ASD have: i) a preference for visual stimuli, ii) a tendency for adaptive functioning, c) research indicates the potential of generalization of skills learned, d) VR and computers for ASD groups is becoming well established; individuals with ASD are drawn to these technologies; there is a need for development of specific and focused interventions/opportunities; ensure that VR is accessible, easy to use and fun; include individuals with ASD in the decision making process, and e) provide coach support (cues and help for involvement/motivation) for individuals with ASD when using a VR system); lower independent task completion in K-12 students compared to higher education students. Also, one expert shared the concern whether "VR can be of practical benefit for ASD" and that trained therapists are "much much better" to VR. Lastly, 2 experts raised the following questions to consider regarding: a) the use of augmented technologies as well as/instead of VR, and b) the use of assistive technologies for the support of individuals with ASD in VR environments; further research of: the biggest challenges associated with supporting learners with ASD in VR; the VR modalities that best suit ASD learners; and the critical areas for learners with ASD in VR.

e-Delphi study: Round - 2

Pg 1 of 8: ***Welcome back!***

Welcome back to e-Delphi study's 2nd round!

**Thank you so much for supporting
and participating to our study!**

**We greatly appreciate your participation and contribution,
your feedback is important!**

e-Delphi study: Round - 2

Pg 2 of 8: ***Questionnaire's outline & additional information***

Questionnaire's outline at a glance!

page 1: Welcome back!
page 2: Questionnaire's outline & additional information.
page 3: The gist, what's in this questionnaire!
page 4: Mild ASD with ID - profile 1 (Q1-Q12: 6 dropdown & 6 multiple choice)
page 5: Mild ASD without ID - profile 2 (Q13-Q24: 6 dropdown & 6 multiple choice)
page 6: Severe ASD with ID - profile 3 (Q25-Q36: 6 dropdown & 6 multiple choice)
page 7: Severe ASD without ID - profile 4 (Q37-Q48: 6 dropdown & 6 multiple choice)
page 8: Additional information question (Q49: optional) - Thank you!
(*Abbreviations:* ASD=Autism Spectrum Disorders, ID=Intellectual Disability)

Additional information

Questions? We are here for you! Do not hesitate to contact us at"akalyv@cc.uoi.gr" and "amikrop@uoi.gr" if you have any questions and/or need anything else.
Study's content and consent: Please know that by submitting this form you consent to your participation in this study. You become aware of this round's content by accessing this form in any manner.

e-Delphi study: Round - 2

Pg 3 of 8: ***The gist, what's in this questionnaire!***

The gist, what's in this questionnaire!

Please read

Helpful & important information before getting started

- **4 ASD profiles: There are 4 different profiles of individuals with ASD (mild/severe) and ID (with/without). ASD is the primary disorder in every profile. The 4 ASD profiles are as follows: 1. mild ASD with ID (profile 1), 2. mild ASD without ID (profile 2), 3. severe ASD with ID (profile 3), and 4. severe ASD without ID (profile 4).**
- **6 sets of skills: There are 6 different sets of skills that the VR activities/tasks target. These are: 1. social skills, 2. communication skills, 3. cognitive skills, 4. daily living/functional life skills, 5. sensorimotor skills, and 6. behavioral and emotional skills.**
- **24 brief dropdown questions: For each of the 4 ASD profiles and 6 sets of targeted skills, please select the best combination for VR system, VR affordances, VR learning affordances and VR task/activity category (e.g., social skills for mild ASD with ID: which VR system etc. would be best for individuals with this profile when targeting social skills?)**
- **24 brief multiple choice questions: Keeping in mind your answer in the preceding dropdown question, please select the set(s) of specific skills individuals with each of the 4 ASD profiles should adequately demonstrate in order to benefit from your previous selection of VR system etc. combination (e.g., social skills for mild ASD with ID: which set(s) of skills should these individuals adequately demonstrate?).**
- **1 optional question: for additional information etc.**

e-Delphi study: Round - 2

Pg 4 of 8: Mild ASD with ID - profile 1
(Q1-Q12: 6 dropdown & 6 multiple choice)

Provided answers/options & abbreviations:

- **VR systems (5): a. Desktop *(i.e., Desktop: desktop or laptop based);* b. Full immersive *(i.e., Full immersive: HMDs);* c. Semi immersive *(i.e., Semi immersive: 3D stereo glasses);* d. MUVEs *(i.e., MUVEs or Virtual Worlds: e.g., SecondLife, OpenSim);* e. Augment. Reality *(i.e., Augmented Reality: desktop or mobile based)***
- **VR affordances (5): a. Real time interaction; b. Immersion; c. Presence; d. Avatars *(i.e., Users' representation through avatars);* e. *1st user point of view (i.e., First-person user point of view)***
- **VR learning affordances (6): a. Free navigation; b. Creation; c. Modeling & simulation; d. Multichannel commun . *(i.e., Multichannel communication);* e. Collaboration&coop. *(i.e., Collaboration and cooperation);* f. Content present/deliv. *(i.e., Content presentation and/or delivery)***
- **VR task/activity categories (5): a. Gaming *(i.e., Games and gamification)*; b. Inquiry&experiment. *(i.e., Inquiry and experimentation)*; c. Interaction w/content *(i.e., Interaction with content)*; d. Social engagement; e. Real-life represent. *(i.e., Real-life skills/routines representations)***
- **Abbreviations: ASD=Autism Spectrum Disorders; ID=Intellectual Disability; VR=Virtual Reality.**

* 1.

Social skills **for** mild ASD with ID

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **social skills** tasks for individuals that have **mild ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Social skills for **mild ASD with ID**				

Other (please specify)

* 2. **Social skills for mild ASD with ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q1**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **social skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 3. **Communication skills for mild ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **communication skills** tasks for individuals that have **mild ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Commu-nication skills for **mild ASD with ID**				

Other (please specify)

* 4. **Communication skills for mild ASD with ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q3**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **communication skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 5. **Cognitive skills for mild ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordance*****, s** and ***VR task/activity category*** for the design of **cognitive skills** tasks for individuals that have **mild ASD with ID.** (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Cognitive skills for **mild ASD with ID**				

Other (please specify)

* 6. **Cognitive skills for mild ASD with ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q5**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **cognitive skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 7. **Daily living/functional life skills** **for** **mild ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **daily living/functional life skills** tasks for individuals that have **mild ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Daily living/ functional life skills for **mild ASD with ID**				

Other (please specify)

* 8. **Daily living/functional life skills** **for** **mild ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q7**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **daily living/functional life skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- ☐ a. Cognitive skills
- ☐ b. Communication skills
- ☐ c. Academic skills
- ☐ d. Motor skills
- ☐ e. Sensory skills
- ☐ f. Computer interest/skills
- ☐ g. All of the above
- ☐ h. N/A
- ☐ i. Other (please specify)

* 9. **Sensorimotor skills** **for** **mild ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **sensorimotor skills** tasks for individuals that have **mild ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Sensori-motor skills for **mild ASD with ID**				

Other (please specify)

* 10. **Sensorimotor skills** **for** **mild ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q9**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **sensorimotor skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 11.
Behavioral & emotional skills for mild ASD with ID

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **behavioral & emotional skills** tasks for individuals that have **mild ASD with ID**. (*__Other:__ Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Behavioral & emotional skills for **mild ASD with ID**				

Other (please specify)

* 12. **Behavioral & emotional skills for mild ASD with ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q11**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **behavioral & emotional skills** tasks in VR. (*__Other:__ Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

e-Delphi study: Round - 2

*Pg 5 of 8: **Mild ASD without ID** - profile 2*
(Q13-Q24: 6 dropdown & 6 multiple choice)

Provided answers/options & abbreviations:

- **VR systems (5): a. Desktop (i.e., Desktop: desktop or laptop based); b. Full immersive (i.e., Full immersive: HMDs); c. Semi immersive (i.e., Semi immersive: 3D stereo glasses); d. MUVEs (i.e., MUVEs or Virtual Worlds: e.g., SecondLife,**

OpenSim); e. Augment. Reality (i.e., Augmented Reality: desktop or mobile based)

- **VR affordances (5): a. Real time interaction; b. Immersion; c. Presence; d. Avatars (i.e., Users' representation through avatars); e. 1st user point of view (i.e., First-person user point of view)**
- **VR learning affordances (6): a. Free navigation; b. Creation; c. Modeling & simulation; d. Multichannel commun. (i.e., Multichannel communication); e. Collaboration&coop. (i.e., Collaboration and cooperation); f. Content present/deliv. (i.e., Content presentation and/or delivery)**
- **VR task/activity categories (5): a. Gaming (i.e., Games and gamification); b. Inquiry&experiment. (i.e., Inquiry and experimentation); c. Interaction w/content (i.e., Interaction with content); d. Social engagement; e. Real-life represent. (i.e., Real-life skills/routines representations)**
- **Abbreviations: ASD=Autism Spectrum Disorders; ID=Intellectual Disability; VR=Virtual Reality.**

* 13. **Social skills for mild ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **social skills** tasks for individuals that have **mild ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Social skills for **mild ASD without ID**				

Other (please specify)

* 14. **Social skills for mild ASD without ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q13**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **social skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 15. **Communication skills for mild ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **communication skills** tasks for individuals that have **mild ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Commu-nication skills for mild ASD without ID				

Other (please specify)

* 16. **Communication skills for mild ASD without ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q15**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **communication skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- a. Cognitive skills
- b. Communication skills
- c. Academic skills
- d. Motor skills
- e. Sensory skills
- f. Computer interest/skills
- g. All of the above
- h. N/A
- i. Other (please specify)

* 17. **Cognitive skills for mild ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **cognitive skills** tasks for individuals that have **mild ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Cognitive skills for **mild ASD without ID**				

Other (please specify)

* 18. **Cognitive skills for mild ASD without ID** and individuals' **set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q17**), please select in your opinion the specific **set(s) of skills** individuals that have **mild ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **cognitive skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- ☐ a. Cognitive skills
- ☐ b. Communication skills
- ☐ c. Academic skills
- ☐ d. Motor skills
- ☐ e. Sensory skills
- ☐ f. Computer interest/skills
- ☐ g. All of the above
- ☐ h. N/A
- ☐ i. Other (please specify)

* 19. **Daily living/functional life skills** **for** **mild ASD** **without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **daily living/functional life skills** tasks for individuals that have **mild ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Daily living/ func-tional life skills for **mild ASD without ID**				

Other (please specify)

* 20. **Daily living/functional life skills** **for** **mild ASD** **without ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q19**), please select in your opinion the specific **set(s) of skills** individuals that have **mild** **ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **daily living/functional life skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 21. **Sensorimotor skills** **for** **mild ASD** **without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **sensorimotor skills** tasks for individuals that have **mild** **ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns'* option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Sensori-motor skills for **mild ASD** **without ID**				

Other (please specify)

* 22. **Sensorimotor skills** **for** **mild ASD** **without ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q21**), please select in your opinion the specific **set(s) of skills** individuals that have **mild** **ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **sensorimotor skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- ☐ a. Cognitive skills
- ☐ b. Communication skills
- ☐ c. Academic skills
- ☐ d. Motor skills
- ☐ e. Sensory skills
- ☐ f. Computer interest/skills
- ☐ g. All of the above
- ☐ h. N/A
- ☐ i. Other (please specify)

* 23. **Behavioral & emotional skills** **for** mild **ASD** **without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **behavioral & emotional skills** tasks for individuals that have **mild ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Behavioral & emotional skills for mild **ASD** **without ID**				

Other (please specify)

* 24. **Behavioral & emotional skills** **for** mild **ASD** **without ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q23**), please select in your opinion the specific **set(s) of skills** individuals that have **mild** **ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **behavioral & emotional skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

e-Delphi study: Round - 2

*Pg 6 of 8: **Severe ASD with ID** - profile 3*
(Q25-Q36: 6 dropdown & 6 multiple choice)

Provided answers/options & abbreviations:

- VR systems (5): **a. Desktop (i.e., Desktop: desktop or laptop based); b. Full immersive (i.e., Full immersive: HMDs); c. Semi immersive (i.e., Semi immersive: 3D stereo glasses); d. MUVEs (i.e., MUVEs or Virtual Worlds: e.g., SecondLife, OpenSim); e. Augment. Reality (i.e., Augmented Reality: desktop or mobile based)**

- **VR affordances (5):** **a. Real time interaction; b. Immersion; c. Presence; d. Avatars (i.e., Users' representation through avatars); e. 1st user point of view (i.e., First-person user point of view)**
- **VR learning affordances (6):** **a. Free navigation; b. Creation; c. Modeling & simulation; d. Multichannel commun. (i.e., Multichannel communication); e. Collaboration&coop. (i.e., Collaboration and cooperation); f. Content present/deliv. (i.e., Content presentation and/or delivery)**
- **VR task/activity categories (5):** **a. Gaming (i.e., Games and gamification); b. Inquiry&experiment. (i.e., Inquiry and experimentation); c. Interaction w/content (i.e., Interaction with content); d. Social engagement; e. Real-life represent. (i.e., Real-life skills/routines representations)**
- **Abbreviations:** **ASD=Autism Spectrum Disorders; ID=Intellectual Disability; VR=Virtual Reality.**

* 25. **Social skills for severe ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*, **and ***VR task/activity category*** for the design of **social skills** tasks for individuals that have **severe ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Social skills for **severe ASD with ID**				

Other (please specify)

* 26. **Social skills for severe ASD with ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q25**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **social skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- ☐ a. Cognitive skills
- ☐ b. Communication skills
- ☐ c. Academic skills
- ☐ d. Motor skills
- ☐ e. Sensory skills
- ☐ f. Computer interest/skills
- ☐ g. All of the above
- ☐ h. N/A
- ☐ i. Other (please specify)

* 27. **Communication skills** **for** **severe ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **communication skills** tasks for individuals that have **severe ASD with ID**. (**Other:* Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Commu-nication skills for **severe ASD with ID**				

Other (please specify)

* 28. **Communication skills** **for** **severe ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q27**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **communication skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 29. **Cognitive skills** **for** **severe ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **cognitive skills** tasks for individuals that have **severe ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Cognitive skills for **severe ASD with ID**				

Other (please specify)

* 30. **Cognitive skills** **for** **severe ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q29**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **cognitive skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 31. Daily living/functional life skills **for** severe ASD with ID

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of daily living/functional life skills tasks for individuals that have **severe ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Daily living/ func-tional life skills for severe ASD with ID				

Other (please specify)

* 32. Daily living/functional life skills **for** severe ASD with ID **and** individuals' set(s) of skills

Keeping in mind your **answer in the previous** question (**Q31**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting daily living/functional life skills tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 33. **Sensorimotor skills** **for** **severe ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **sensorimotor skills** tasks for individuals that have **severe ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Sensori-motor skills for **severe ASD with ID**				

Other (please specify)

* 34. **Sensorimotor skills** **for** **severe ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q33**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **sensorimotor skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 35. **Behavioral & emotional skills** **for** **severe ASD with ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **behavioral & emotional skills** tasks for individuals that have **severe ASD with ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Behavioral & emotional skills for **severe ASD with ID**				

Other (please specify)

* 36. **Behavioral & emotional skills** **for** **severe ASD with ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q35**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD with ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **behavioral & emotional skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

e-Delphi study: Round - 2

*Pg 7 of 8: **Severe ASD** without ID - profile 4*
(Q36-Q48: 6 dropdown & 6 multiple choice)

Provided answers/options & abbreviations:

- VR systems (5): **a. Desktop (i.e., Desktop: desktop or laptop based); b. Full immersive (i.e., Full immersive: HMDs); c. Semi immersive (i.e., Semi immersive: 3D stereo glasses); d. MUVEs (i.e., MUVEs or Virtual Worlds: e.g., SecondLife, OpenSim); e. Augment. Reality (i.e., Augmented Reality: desktop or mobile based)**

- **VR affordances (5): a. Real time interaction; b. Immersion; c. Presence; d. Avatars (i.e., Users' representation through avatars); e. 1st user point of view (i.e., First-person user point of view)**
- **VR learning affordances (6): a. Free navigation; b. Creation; c. Modeling & simulation; d. Multichannel commun. (i.e., Multichannel communication); e. Collaboration&coop. (i.e., Collaboration and cooperation); f. Content present/deliv. (i.e., Content presentation and/or delivery)**
- **VR task/activity categories (5): a. Gaming (i.e., Games and gamification); b. Inquiry&experiment. (i.e., Inquiry and experimentation); c. Interaction w/content (i.e., Interaction with content); d. Social engagement; e. Real-life represent. (i.e., Real-life skills/routines representations)**
- **Abbreviations: ASD=Autism Spectrum Disorders; ID=Intellectual Disability; VR=Virtual Reality.**

* 37. **Social skills for severe ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances***, and ***VR task/activity category*** for the design of **social skills** tasks for individuals that have **severe ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Social skills for severe ASD without ID				

Other (please specify)

* 38. **Social skills for severe ASD without ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q37**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **social skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 39. **Communication skills** **for** **severe ASD** **without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **communication skills** tasks for individuals that have **severe** **ASD** **without** **ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Commu-nication skills for **severe ASD without ID**				

Other (please specify)

* 40. **Communication skills** **for** **severe ASD** **without ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q39**), please select in your opinion the specific **set(s) of skills** individuals that have **severe** **ASD** **without** **ID** will need to **adequately** demonstrate in order to access and benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **communication skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 41. Cognitive skills **for** severe ASD without ID

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **cognitive skills** tasks for individuals that have **severe ASD without ID**. (*__Other:__ Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Cognitive skills for severe ASD without ID				

Other (please specify)

* 42. Cognitive skills **for** severe ASD without ID **and** individuals' set(s) of skills

Keeping in mind your **answer in the previous** question (**Q41**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **cognitive skills** tasks in VR. (*__Other:__ Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 43. Daily living/functional life skills **for** severe ASD without ID

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of daily living/functional life skills tasks for individuals that have **severe ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Daily living/ func- tional life skills for severe ASD without ID				

Other (please specify)

* 44. Daily living/functional life skills **for** severe ASD without ID **and** individuals' set(s) of skills

Keeping in mind your **answer in the previous** question (**Q43**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting daily living/functional life skills tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

* 45. **Sensorimotor skills for severe ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **sensorimotor skills** tasks for individuals that have **severe ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Sensori-motor skills for **severe ASD without ID**				

Other (please specify)

* 46. **Sensorimotor skills for severe ASD without ID and individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q45**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **sensorimotor skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- a. Cognitive skills
- b. Communication skills
- c. Academic skills
- d. Motor skills
- e. Sensory skills
- f. Computer interest/skills
- g. All of the above
- h. N/A
- i. Other (please specify)

* 47. **Behavioral & emotional skills** **for** **severe ASD without ID**

Please select the **best** in your opinion overall combination for ***VR system***, ***VR affordances***, ***VR learning affordances*****,** and ***VR task/activity category*** for the design of **behavioral & emotional skills** tasks for individuals that have **severe ASD without ID**. (***Other:** Please go to 'Other' and specify, if your preferred answer(s) and/or combination of *columns*' option(s) is not listed and/or you wish to provide additional information/clarifications.)

	VR system	VR affordances	VR learning affordances	VR task/ activity category
Behavioral & emotional skills for **severe ASD without ID**				

Other (please specify)

* 48. **Behavioral & emotional skills** **for** **severe ASD without ID** **and** **individuals' set(s) of skills**

Keeping in mind your **answer in the previous** question (**Q47**), please select in your opinion the specific **set(s) of skills** individuals that have **severe ASD without ID** will need to **adequately** demonstrate in order to benefit from the combination of VR system, VR affordances, VR learning affordances, and VR task/activity category you previously selected when targeting **behavioral & emotional skills** tasks in VR. (***Other:** Please select (also) 'Other' and specify, if your preferred answer(s) and/or combination of option(s) is not listed and/or you wish to provide additional information/clarifications.)

- [ ] a. Cognitive skills
- [ ] b. Communication skills
- [ ] c. Academic skills
- [ ] d. Motor skills
- [ ] e. Sensory skills
- [ ] f. Computer interest/skills
- [ ] g. All of the above
- [ ] h. N/A
- [ ] i. Other (please specify)

e-Delphi study: Round - 2

Pg 8 of 8: Additional information question (Q49: optional) - Thank you!

49. Overall, is there anything else you would like to add?**Thank you!**

E-DELPHI STUDY: SUMMARY OF ROUND-2 AND INTRODUCTION – HELPFUL INFORMATION FOR ROUND-3

Summary of Round-2

In the study's second round experts were presented with the following four different profiles of individuals with ASD[1]: i) mild ASD with ID (Profile 1), ii) mild ASD without ID (Profile 2), iii) severe ASD with ID (Profile 3), and iv) severe ASD without ID (Profile 4). It was suggested that experts consider designing tasks in VR for individuals with ASD to work on the following six targeted skills areas: 1. social skills, 2. communication skills, 3. cognitive skills, 4. daily living/functional life skills, 5. sensorimotor skills, and 6. behavioral and emotional skills.

Next, and while keeping in mind the four different ASD profiles (Profiles 1-4) as well as the six targeted skills areas, experts selected the VR combination (comprised from a VR system, a VR affordance, a VR learning affordance, and a VR task/activity category) that in their opinion would be the most appropriate for each case. Experts were also asked to select Individuals' Specific Skills Set (ISSS), i.e., a specific set of skills that individuals with each ASD profile should adequately demonstrate in order to benefit from the proposed VR combinations - it is noted that ISSSs[2] are differentiated from the six targeted skill areas. For a schematic representation of Round 2 please see Figure 1.

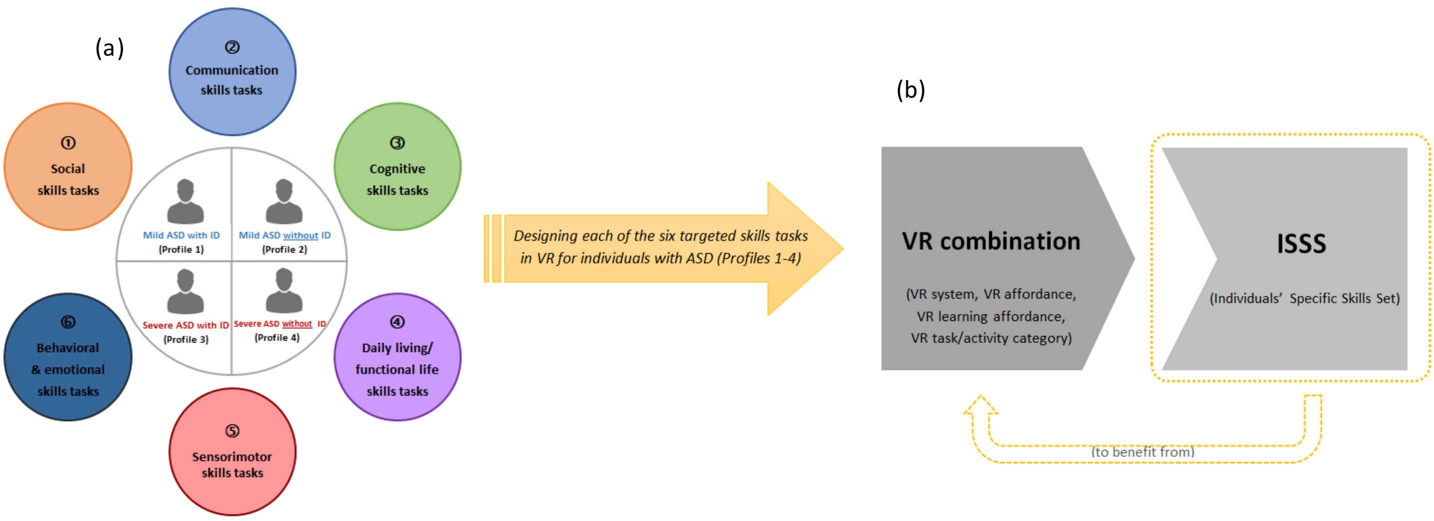

Figure 1. Six targeted skill areas for the respective design of tasks in VR, suitable for individuals with ASD Profiles 1-4 (a). Selection of the appropriate VR combination and ISSS in order for individuals with ASD to receive benefit from the VR combination (b).

[1] Please see in the Appendix for a list with all the abbreviations and terms (p.4).
[2] A list of the ISSSs included in Round 3 can be seen in the last section of Figure 2 (p.2).

The proposed VR combinations and Individuals' Specific Set of Skills (ISSS) from Round 2 were processed in reference to the four ASD profiles and each of the six targeted skills. The results with the highest number of occurrences (mode) from each value (VR system, VR affordances, VR learning affordances, VR task/activity category, and Individuals' Specific skill Set) were selected and presented in Round 3 (Figure 2).

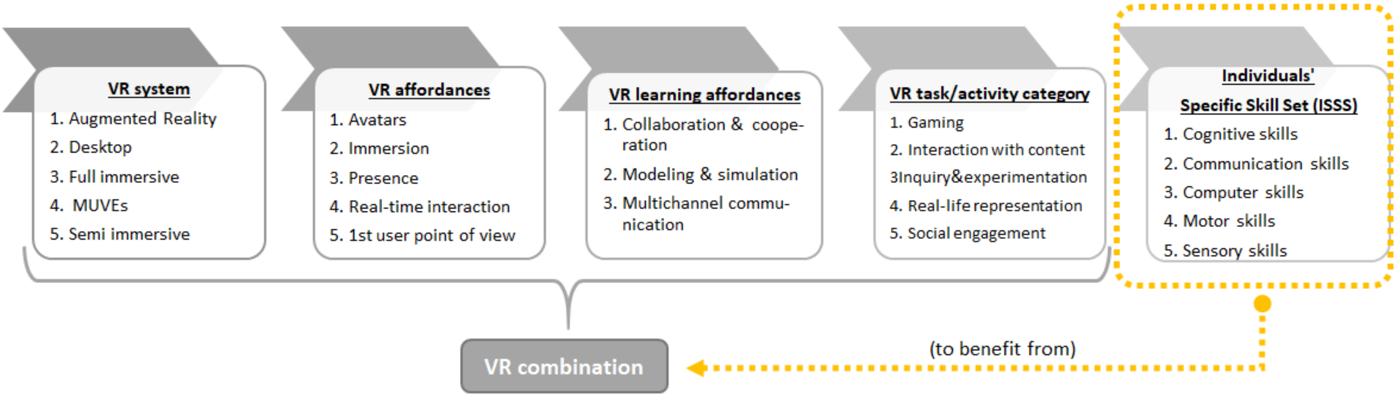

Figure 2. Results with the highest frequency (mode) from Round 2. Listed in alphabetical order and for each of the five values (VR system, VR affordances, VR learning affordances, VR task/activity category, and ISSS).

Introduction – Helpful information for Round 3

As previously mentioned, Round 2's results with the highest frequency for each of the five values (VR system, VR affordances, VR learning affordances, VR task/activity category, and ISSS) went through to Round 3. They will now appear in the form of rating statements for Round 3's Questionnaire. Thus, in Round 3 there are four groups with statements, one for each ASD profile, to be rated in a 5point Likert scale (agree/disagree) .

Each of the four groups of rating statements has two categories of rating items. The first category concerns the VR combinations for the design of tasks regarding the targeted skills and with respect to the individuals' ASD profile (Profiles 1-4). The second category concerns the Individuals' Specific Set of Skills (ISSS) that they should adequately demonstrate in order to benefit from the corresponding VR combination (for the design of tasks for each of the six targeted skill areas). Each time the VR combination is provided first and then the corresponding ISSS follows. You will see that this alternation applies to all the VR combinations and ISSSs included in each group.

In regards to the VR combinations, some appear to be similar. However, they are different in at least one of their four components and/or concern the design of a different skill task. Following each VR combination, there is one or two corresponding ISSSs to be rated. Please note that regardless if there is one or two ISSSs for a VR combination, each ISSS is considered as a stand-alone specific skill set and therefore it is independently rated at all times. Lastly, the rating statements are color-coded and grouped per designed skill tasks (i.e., social skills, communication skills, cognitive skills, daily living/functional life skills, sensorimotor skills, and behavioral & emotional skills). Please see Figure 3 for a snapshot from Round 3's Questionnaire and an example of the rating statements for the case of individuals that have mild ASD with ID (Profile 1) and the design of social skills in VR[3].

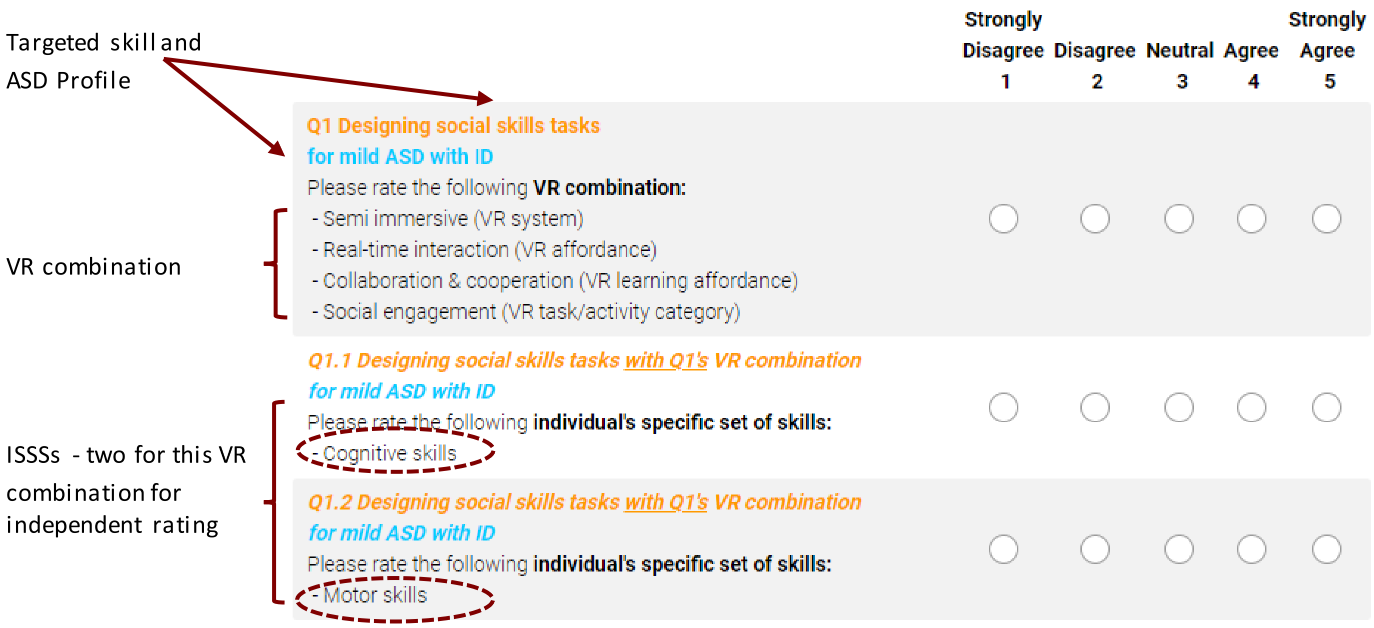

Figure 3. Snapshot from Round 3's Questionnaire; rating statements and 5point Likert scale (agree/disagree). In this example the rating statements concern individuals that have mild ASD with ID. The tasks designed in VR target individuals' social skills. The VR combination is provided and rated firstly and the ISSSs follow. In this case there are two ISSSs corresponding to this particular VR combination - ISSSs are noted to be rated independently at all times.

[3] The same concept applies also for individuals with Profiles 2, 3 and 4 as well as the design of the remaining skills tasks (e.g., communication skill tasks, cognitive skills tasks etc.)

Appendix

Abbreviations
ASD: Autism Spectrum Disorders
ID: Intellectual Disability
VR: Virtual Reality
ISSS: Individuals' Specific Skill Set

Terms
Desktop: desktop or laptop based
Full immersive: HMDs
Semi immersive: 3D stereo glasses
MUVEs: MUVEs or Virtual Worlds: e.g., SecondLife, OpenSim
Augmented Reality: desktop or mobile based
Avatars: users' representation through avatars
Gaming: games and gamification
Real-life representations: real-life skills/routines representations

e-Delphi study: Round - 3

We greatly appreciate your returning for this last round - welcome back!

Thank you very much
for your valuable help and support!

*****Your feedback is important to the study's final findings*****

- **Study's content and consent: Please know that by submitting this form you consent to your participation in this study. You become aware of this round's content by accessing this form in any manner.**
- **Consent for acknowledgment: Please give us your consent to acknowledge your contribution to our study (Q5). Thank you again for your participation!**
- **Questions? Do not hesitate to contact us at "akalyv@cc.uoi.gr" and "amikrop@uoi.gr" if you have any questions and/or need anything else.**

e-Delphi study: Round - 3

(*Abbreviations.* ASD: Autism Spectrum Disorders, ID: Intellectual Disability, VR: Virtual Reality)

Important information for Round 3!
Please read

- **4 rating sets. There are 4 groups of items to be rated. Each group corresponds to one of the four different ASD profiles, i.e. mild ASD with ID (Profile 1); mild ASD <u>without</u> ID (Profile 2); severe ASD with ID (Profile 3); and severe ASD <u>without</u> ID (Profile 4).**
- **2 categories of rating items per set. Every rating group has two categories of rating items, one concerning VR combinations, and the other concerning ASD individuals' specific set of skills.**
- **1st category, rating VR combinations (5point Likert scale). Each VR combination has four components, i.e. a VR system, a VR affordance, a VR learning affordance, and a VR task/activity category. Some VR combinations appear to be similar. However, they are different in at least one of their four components and/or concern the design of a different skill task. The VR combinations are color-coded and grouped per targeted skill area. There are six targeted skill areas and thus six types of designed tasks, i.e. social skills tasks, communication skills tasks, cognitive skills tasks, daily living/functional life skills tasks, sensorimotor skills tasks, and behavioral & emotional skills tasks.**
- **2nd category, rating individuals' specific set of skills (5point Likert scale). The Individuals' Specific Skill Set (ISSS) is that set of skills (i.e., academic skills, communication skills, cognitive skills, computer skills, motor skills, and sensory skills) that the individual with a particular ASD profile (e.g., Profile 1), should adequately demonstrate in order to benefit from**

the corresponding VR combination, used for the design of the previously mentioned six targeted skills areas. Every VR combination has 1 or 2 corresponding ISSSs, each being a stand-alone specific skill set and rated independently.

e-Delphi study: Round - 3

Introduction to Round 3 (tables, questions, rating items)

Introduction to Round 3!

Please read

- Each of the four next pages refers to a specific ASD profile. At the beginning of those pages, you will first see how many rating items are included in that rating group. The rating items concern the VR combinations and the ISSSs (in each question you will find only those ISSSs that apply for the pertinent ASD profile).

- A comprehensive table with the distribution of the rating items (color-coded & grouped per designed skills tasks) is also provided. Please take a moment to locate the cases where VR combinations have two ISSSs to be rated independently at all times.

- Next, you will see the general question that applies to all items of that group. Each time the VR combination is provided first and then the corresponding ISSS follows. You will see that this alternation applies to all the VR combinations and ISSSs included in each group.

Abbreviations & terms

Abbreviations. ASD: Autism Spectrum Disorders, ID: Intellectual Disability, VR: Virtual Reality, ISSS: Individuals' Specific Skills.

Terms. Desktop (desktop or laptop based), Full immersive (HMDs), Semi immersive (3D stereo glasses), MUVEs (MUVEs or Virtual Worlds: e.g., SecondLife, OpenSim), Augmented Reality (desktop or mobile based), Avatars (users' representation through avatars), Gaming (games and gamification), Real-life representations (real-life skills/routines representations).

****** Thank you!******

e-Delphi study: Round - 3

Mild ASD with ID (Profile 1)

There are 36 items to be rated, all regarding individuals that have mild ASD with ID (Profile 1):
- 17 items concern VR combinations[1] and
- 19 items concern Individual's Specific Set of Skills (ISSSs)

Profile 1: Distribution of 36 items (color-coded & grouped per designed skills tasks)							
Social skills tasks (Q1-Q2)	Communication skills tasks (Q3-Q11)	Cognitive skills tasks (Q12-Q13)	Daily living/ functional life skills tasks (Q14)	Sensorimotor skills tasks (Q15-Q16)	Behavioral & emotional skills tasks (Q17)	Totals
2 VR combos 4 ISSSs[2]	9 VR combos 9 ISSSs	2 VR combos 2 ISSSs	1 VR combo 1 ISSS	2 VR combos 2 ISSSs	1 VR combo 1 ISSS	17VR combos 19ISSSs

[1]VR combo: VR system, VR affordance, VR learning affordance and VR task/activity category.

[2]Two different & stand-alone ISSSs per VR combo for the design of these skills tasks - to be independently rated.

* 1. **Mild ASD with ID (Profile 1)**

On a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)**, please rate:

- the **VR combinations** (i.e., VR system, VR affordance, VR learning affordance, and VR task/activity category) for designing respectively social skills tasks, communication skills tasks, cognitive skills tasks, daily living/functional life skills tasks, sensorimotor skills tasks, and behavioral & emotional skills tasks for individuals with Profile 1.

- the **individuals' specific set of skills** (i.e., cognitive skills, motor skills, communication skills, and computer skills), that they should adequately demonstrate in order to benefit from the corresponding VR combination (for the VR combinations with two individuals' specific skills sets to be rated please rate each of them independently and as a stand-alone specific skills set.)

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q1 Designing social skills tasks for mild ASD with ID Please rate the following **VR combination:** - Semi immersive (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q1.1 Designing social skills tasks with Q1's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills:** - Cognitive skills	○	○	○	○	○
Q1.2 Designing social skills tasks with Q1's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills:** - Motor skills	○	○	○	○	○
Q2 Designing social skills tasks for mild ASD with ID Please rate the following **VR combination:** - Semi immersive (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q2.1 Designing social skills tasks with Q2's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills:** - Cognitive skills	○	○	○	○	○
Q2.2 Designing social skills tasks with Q2's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills:** - Motor skills	○	○	○	○	○
Q3 Designing communication skills tasks for mild ASD with ID Please rate the following **VR combination:** - Full immersive (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q3.1 Designing communication skills tasks with Q3's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q4 Designing communication skills tasks for mild ASD with ID Please rate the following **VR combination**: - Full immersive (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q4.1 Designing communication skills tasks with Q4's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q5 Designing communication skills tasks for mild ASD with ID Please rate the following **VR combination:** - Full immersive (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q5.1 Designing communication skills tasks with Q5's VR combination for mild ASD with ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q6 Designing communication skills tasks for mild ASD with ID Please rate the following **VR combination**: - MUVEs (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q6.1 Designing communication skills tasks ***with Q6's*** ***VR combination*** ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q7 Designing communication skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - MUVEs (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q7.1 Designing communication skills tasks ***with Q7's*** ***VR combination*** ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q8 Designing communication skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - MUVEs (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q8.1 Designing communication skills tasks ***with Q8's*** ***VR combination*** ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q9 Designing communication skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Augmented Reality (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q9.1 Designing communication skills tasks ***with Q9's*** ***VR combination*** ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q10 Designing communication skills tasks **for mild ASD with ID** Please rate the following **VR- combination**: - Augmented Reality (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q10.1 Designing communication skills tasks ***with Q10's*** ***VR combination*** ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q.11 Designing communication skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Augmented Reality (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q11.1 Designing communication skills tasks with Q11's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q12 Designing cognitive skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Inquiry & experimentation (VR task/activity category)	○	○	○	○	○
Q12.1 Designing cognitive skills tasks with Q12's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q13 Designing cognitive skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task/activity category)	○	○	○	○	○
Q13.1 Designing cognitive skills tasks with Q13's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q14 Designing daily living/functional life skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Augmented Reality (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Real life representation (VR task/activity category)	○	○	○	○	○
Q14.1 Designing daily living/functional life skills tasks with Q14's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q15 Designing sensorimotor skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Full immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task/activity category)	○	○	○	○	○
Q15.1 Designing sensorimotor skills tasks with Q15's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q16 Designing sensorimotor skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Semi immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task/activity category)	○	○	○	○	○
Q16.1 Designing sensorimotor skills tasks with Q16's VR combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q17 Designing behavioral & emotional skills tasks **for mild ASD with ID** Please rate the following **VR combination**: - Full immersive (VR system) - Presence (VR affordance) - Modeling & simulation (VR learning affordance) - Social engagement (VR task/activity category)	○	○	○	○	○
Q17.1 Designing behavioral & emotional skills tasks with Q17's combination ***for mild ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○

e-Delphi study: Round - 3

Mild ASD without ID (Profile 2)

There are 23 items to be rated, all regarding individuals that have mild ASD without ID (Profile 2):

- 10 items concern VR combinations[1] and

- 13 items concern Individual's Specific Set of Skills (SSSs).

Profile 2: Distribution of 23 items (color-coded & grouped per designed skills tasks)						
Social skills tasks (Q18-Q19)	Communication skills tasks (Q20-Q21)	Cognitive skills tasks (Q22-Q23)	Daily living/ functional life skills tasks (Q24-Q25)	Sensorimotor skills tasks (Q26)	Behavioral & emotional skills tasks (Q27)	Total
2 VRcombos 2 ISSSs	2 VRcombos 2 ISSSs	2 VRcombos 2 ISSSs	2 VRcombo 4 ISSSs[2]	1 VRcombo 2 ISSSs[2]	1 VRcombo 1 ISSS	10VRcombos 13ISSSs

[1]VRcombo:VR system,VR affordance,VR learning affordance&VRtask/activity category.

[2]Two different&stand-alone ISSSs per VR combo for the design of these skills tasks-please rate independently

* 2.

Mild ASD without ID (Profile 2)

On a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)**, please rate:

\- the **VR combinations** (i.e., VR system, VR affordance, VR learning affordance, and VR task/activity category) for designing respectively social skills tasks, communication skills tasks, cognitive skills tasks, daily living/functional life skills tasks, sensorimotor skills tasks, and behavioral & emotional skills tasks for individuals with Profile 2.

\- the **individuals' specific set of skills** (i.e., communication skills, cognitive skills, motor skills, and sensory skills), that they should adequately demonstrate in order to benefit from the corresponding VR combination (for the VR combinations with two individuals' specific skills sets to be rated please rate each of them independently and as a stand-alone specific skills set.)

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q18 Designing social skills tasks for mild ASD without ID Please rate the following **VR combination**: - MUVEs (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q18.1 Designing social skills tasks with Q18's VR combination for mild ASD without ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q19 Designing social skills tasks for mild ASD without ID Please rate the following **VR combination:** - MUVEs (VR system) - Presence (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q19.1 Designing social skills tasks with Q19's VR combination for mild ASD without ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q20 Designing communication skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Avatars (VR affordance) - Multichannel communication (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q20.1 Designing communication skills tasks <u>with Q20's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q21 Designing communication skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - MUVEs (VR system) - Avatars (VR affordance) - Multichannel communication (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q21.1 Designing communication skills tasks <u>with Q21's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q22 Designing cognitive skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Inquiry & experimentation (VR task activity/category)	○	○	○	○	○
Q22.1 Designing cognitive skills tasks <u>with Q22's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Cognitive skills	○	○	○	○	○
Q23 Designing cognitive skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Desktop (VR system) - 1st user point of view (VR affordance) - Modeling & simulation (VR learning affordance) - Inquiry & experimentation (VR task activity/category)	○	○	○	○	○
Q23.1 Designing cognitive skills tasks <u>with Q23's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Cognitive skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q24 Designing daily living/functional life skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Augmented Reality (VR system) - Presence (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q24.1 Designing daily living/functional life skills tasks <u>with Q24's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Cognitive skills	○	○	○	○	○
Q24.2 Designing daily living/functional life skills tasks <u>with Q24's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q25 Designing daily living/functional life skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Augmented Reality (VR system) - Avatars (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q25.1 Designing daily living/functional life skills tasks <u>with Q25's</u> combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Cognitive skills	○	○	○	○	○
Q25.2 Designing daily living/functional life skills tasks <u>with Q25's</u> combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q26 Designing sensorimotor skills tasks **for mild ASD <u>without</u> ID** Please rate the following **VR combination**: - Semi immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q26.1 Designing sensorimotor skills tasks <u>with Q26's</u> VR combination ***for mild ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q26.2 Designing sensorimotor skills tasks <u>with Q26's</u> VR combination for mild ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Sensory skills	○	○	○	○	○
Q27 Designing behavioral & emotional skills tasks for mild ASD <u>without</u> ID Please rate the following **VR combination**: - Semi immersive (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q27.1 Designing behavioral & emotional skills tasks <u>with Q27's</u> VR combination for mild ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○

e-Delphi study: Round - 3

Severe ASD with ID (Profile 3)

There are 30 items to be rated, all regarding individuals that have severe ASD with ID (Profile 3):

- 13 items concern VR combinations[1] and

- 17 items concern Individual's Specific Set of Skills (ISSSs).

Profile 3: Distribution of 30 items (color-coded & grouped per designed skills tasks)						
Social skills tasks (Q28)	Communication skills tasks (Q29-Q30)	Cognitive skills tasks (Q31-Q32)	Daily living/ functional life skills tasks (Q33-Q34)	Sensorimotor skills tasks (Q35-Q38)	Behavioral & emotional skills tasks (Q39-Q40)	Totals
1 VR combo 1 ISSS	2 VR combos 2 ISSSs	2 VR combos 2 ISSSs	2 VR combos 2 ISSSs	4 VR combos 8 ISSSs[2]	2 VR combos 2 ISSSs	13VR combos 17ISSSs

[1]VRcombo: VR system, VR affordance, VR learning affordance &VR task/activity category.

[2]Two different & stand-alone ISSSs per VR combo for the design of these skills tasks - to be <u>independently</u> rated.

* 3. **Severe ASD with ID (Profile 3)**

On a scale from **1 (Strongly Disagree)** to **5 (Strongly Agree)**, please rate:

- the **VR combinations** (i.e., VR system, VR affordance, VR learning affordance, and VR task/activity category) for designing respectively social skills tasks, communication skills tasks, cognitive skills tasks, daily living/functional life skills tasks, sensorimotor skills tasks, and behavioral & emotional skills tasks for individuals with Profile 3.

- the **individuals' specific set of skills** (i.e., communication skills, computer skills, motor skills, sensory skills), that they should adequately demonstrate in order to benefit from the corresponding VR combination (for the VR combinations with two individuals' specific skills sets to be rated please rate each of them <u>independently</u> and as a <u>stand-alone</u> specific skills set.)

	Strongly Disagree 1	**Disagree 2**	**Neutral 3**	**Agree 4**	**Strongly Agree 5**
Q28 Designing social skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Modeling & simulation (VR learning affordance) - Social engagement (VR task activity/category)					
Q28.1 Designing social skills tasks <u>with Q28's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills					
Q29 Designing communication skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)					
Q29.1 Designing communication skills tasks <u>with Q29's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills					
Q30 Designing communication skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Multichannel communication (VR learning affordance) - Gaming (VR task activity/category)					
Q30.1 Designing communication skills tasks <u>with Q30's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Communication skills					
Q31 Designing cognitive skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)					

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q31.1 Designing cognitive skills tasks <u>with Q31's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q32 Designing cognitive skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Multichannel communication (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q32.1 Designing cognitive skills tasks <u>with Q32's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q33 Designing daily living/functional life skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Semi immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q33.1 Designing daily living/functional life skills tasks <u>with Q33's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q34 Designing daily living/functional life skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Semi immersive (VR system) - Avatars (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q34.1 Designing daily living/functional life skills tasks <u>with Q34's</u> VR combination ***for severe ASD with ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q35 Designing sensorimotor skills tasks **for severe ASD with ID** Please rate the following **VR combination**: - Semi immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q35.1 Designing sensorimotor skills tasks <u>with Q35's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q35.2 Designing sensorimotor skills tasks <u>with Q35's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Sensory skills	○	○	○	○	○
Q36 Designing sensorimotor skills tasks for severe ASD with ID Please rate the following **VR combination**: - Semi immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q36.1 Designing sensorimotor skills tasks <u>with Q36's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q36.2 Designing sensorimotor skills tasks <u>with Q36's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Sensory skills	○	○	○	○	○
Q37 Designing sensorimotor skills tasks for severe ASD with ID Please rate the following **VR combination**: - Augmented Reality (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q37.1 Designing sensorimotor skills tasks <u>with Q37's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q37.2 Designing sensorimotor skills tasks <u>with Q37's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Sensory skills	○	○	○	○	○
Q38 Designing sensorimotor skills tasks for severe ASD with ID Please rate the following **VR combination**: - Augmented Reality (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q38.1 Designing sensorimotor skills tasks <u>with Q38's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q38.2 Designing sensorimotor skills tasks <u>with Q38's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Sensory skills	○	○	○	○	○
Q39 Designing behavioral & emotional skills tasks for severe ASD with ID Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q.39.1 Designing behavioral & emotional skills tasks <u>with Q39's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q40 Designing behavioral & emotional skills tasks for severe ASD with ID Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q40.1 Designing behavioral & emotional skills tasks <u>with Q40's</u> VR combination for severe ASD with ID Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○

e-Delphi study: Round - 3

Severe ASD <u>without</u> ID (Profile 4)

There are 54 items to be rated, all regarding individuals that have severe ASD without ID (Profile 4):

- 19 items concern VR combinations[1] and

- 35 items concern Individual's Specific Set of Skills (ISSSs).

Profile 4: Distribution of 54 items (color-coded & grouped per designed skills tasks)						
Social skills tasks (Q41)	Communication skills tasks (Q42-Q47)	Cognitive skills tasks (Q48-Q49)	Daily living/ functional life skills tasks (Q50-Q58)	Sensorimotor skill tasks (Q59)	Behavioral & emotional skill tasks (Q60-Q65)	Totals
1 VR combo 2 ISSSs[2]	6 VR combos 6 ISSSs	2 VR combos 2 ISSSs	9 VR combos 18 ISSSs[2]	1 VR combo 1 ISSS	6 VR combos 6 ISSSs	19 VR combos 35 ISSSs

[1]VR combo: VR system, VR affordance, VR learning affordance and VR task/activity category.

[2]Two different & stand-alone ISSSs per VR combo for the design of these tasks - to be independently rated.

* 4.

Severe ASD without ID (Profile 4)

On a scale **from 1 (Strongly Disagree)** to **5 (Strongly Agree)**, please rate:

- the **VR combinations** (i.e., VR system, VR affordance, VR learning affordance, and VR task/activity category) for designing respectively social skills tasks, communication skills tasks, cognitive skills tasks, daily living/functional life skills tasks, sensorimotor skills tasks, and behavioral & emotional skills tasks for individuals with Profile 4.

- the **individuals' specific set of skills** (i.e., communication skills, computer skills, and motor skills), that they should adequately demonstrate in order to benefit from the corresponding VR combination (for the VR combinations with two individuals' specific skills sets to be rated please rate each of them independently and as a stand-alone specific skills set.)

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q41 Designing social skills tasks for severe ASD without ID Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q41.1 Designing social skills tasks with Q41's VR combination for severe ASD without ID Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q41.2 Designing social skills tasks with Q41's VR combination for severe ASD without ID Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q42 Designing communication skills tasks for severe ASD without ID Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q42.1 Designing communication skills tasks with Q42's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q43 Designing communication skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - Real-time interaction (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q43.1 Designing communication skills tasks with Q43's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q44 Designing communication skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q44.1 Designing communication skills tasks with Q44's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q45 Designing communication skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q45.1 Designing communication skills tasks with Q45's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q46 Designing communication skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q46.1 Designing communication skills tasks with Q46's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q47 Designing communication skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Desktop (VR system) - 1st user point of view (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q47.1 Designing communication skills tasks <u>with Q47's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Communication skills	○	○	○	○	○
Q48 Designing cognitive skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Desktop (VR system) - 1st user point of view (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q48.1 Designing cognitive skills tasks <u>with Q48's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q49 Designing cognitive skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Desktop (VR system) - 1st user point of view (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q49.1 Designing cognitive skills tasks <u>with Q49's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q50 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q50.1 Designing daily living/functional life skills tasks <u>with Q50's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q50.2 Designing daily living/functional life skills tasks <u>with Q50's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q51 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersiveVR system: - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q51.1 Designing daily living/functional life skills tasks <u>with Q51's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q51.2 Designing daily living/functional life skills tasks <u>with Q51's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q52 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q52.1 Designing daily living/functional life skills tasks <u>with Q52's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q52.2 Designing daily living/functional life skills tasks <u>with Q52's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q53 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Immersion (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q53.1 Designing daily living/functional life skills tasks <u>with Q53's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q53.2 Designing daily living/functional life skills tasks <u>with Q53's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q54 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Immersion (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q54.1 Designing daily living/functional life skills tasks <u>with Q54's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q54.2 Designing daily living/functional life skills tasks <u>with Q54's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q55 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Immersion (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q55.1 Designing daily living/functional life skills tasks <u>with Q55's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q55.2 Designing daily living/functional life skills tasks <u>with Q55's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q56 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** - Please rate the following **VR combination**: - Full immersive (VR system) - Presence (VR affordance) - Modeling & simulation (VR learning affordance) - Gaming (VR task activity/category)	○	○	○	○	○
Q56.1 Designing daily living/functional life skills tasks <u>with Q56's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q56.2 Designing daily living/functional life skills tasks <u>with Q56's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q57 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Presence (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q57.1 Designing daily living/functional life skills tasks <u>with Q57's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○
Q57.2 Designing daily living/functional life skills tasks <u>with Q57's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q58 Designing daily living/functional life skills tasks **for severe ASD <u>without</u> ID** Please rate the following **VR combination**: - Full immersive (VR system) - Presence (VR affordance) - Modeling & simulation (VR learning affordance) - Real-life representation (VR task activity/category)	○	○	○	○	○
Q58.1 Designing daily living/functional life skills tasks <u>with Q58's</u> VR combination ***for severe ASD <u>without</u> ID*** Please rate the following **individual's specific set of skills**: - Motor skills	○	○	○	○	○

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q58.2 Designing daily living/functional life skills tasks with Q58's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Computer skills	◯	◯	◯	◯	◯
Q59 Designing sensorimotor skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Full immersive (VR system) - Real-time interaction (VR affordance) - Modeling & simulation (VR learning affordance) - Interaction with content (VR task activity/category)	◯	◯	◯	◯	◯
Q59.1 Designing sensorimotor skills tasks with Q59's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Motor skills	◯	◯	◯	◯	◯
Q60 Designing behavioral & emotional skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	◯	◯	◯	◯	◯
Q60.1 Designing behavioral & emotional skills tasks with Q60's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Computer skills	◯	◯	◯	◯	◯
Q61 Designing behavioral & emotional skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Desktop (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	◯	◯	◯	◯	◯
Q61.1 Designing behavioral & emotional skills tasks with Q61's VR combination ***for severe ASD without ID*** Please rate the following **individual's specific set of skills**: - Computer skills	◯	◯	◯	◯	◯
Q62 Designing behavioral & emotional skills tasks **for severe ASD without ID** Please rate the following **VR combination**: - Full immersive (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	◯	◯	◯	◯	◯

	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Q62.1 Designing behavioral & emotional skills tasks <u>with Q62's</u> VR combination for severe ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q63 Designing behavioral & emotional skills tasks for severe ASD <u>without</u> ID Please rate the following **VR combination**: - Full immersive (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q63.1 Designing behavioral & emotional skills tasks <u>with Q63's</u> VR combination for severe ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q64 Designing behavioral & emotional skills tasks for severe ASD <u>without</u> ID Please rate the following **VR combination**: - MUVEs (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Interaction with content (VR task activity/category)	○	○	○	○	○
Q64.1 Designing behavioral & emotional skills tasks <u>with Q64's</u> VR combination for severe ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○
Q65 Designing behavioral & emotional skills tasks for severe ASD <u>without</u> ID Please rate the following **VR combination**: - MUVEs (VR system) - Avatars (VR affordance) - Collaboration & cooperation (VR learning affordance) - Social engagement (VR task activity/category)	○	○	○	○	○
Q65.1 Designing behavioral & emotional skills tasks <u>with Q65's</u> VR combination for severe ASD <u>without</u> ID Please rate the following **individual's specific set of skills**: - Computer skills	○	○	○	○	○

Thank you for your participation!

* 5. It would be our honor to thank you and acknowledge your valuable participation and contribution to our study! Do you consent to mention your name in the study's acknowledgments (i.e., including and not limited to the dissertation and any future publications)?

- ○ Yes, I give my consent.
- ○ No, thank you.
- ○ Other (please specify)