APPENDIX A : IRB PROTOCOL

Adult-Child Differences in Route Learning in an Immersive Virtual Environment as a Function of FOV

by Faith A. McCreary

Justification of Project

Virtual environments (VEs) have the potential to change the way students learn. They offer students the opportunity to actively interact with a computer-generated simulation of a real or imaginary environment in an intuitive manner. They provide students with the illusion of actually being in an environment that they might otherwise never experience. Today's educational VEs allow children to explore villas in Ancient Greece, perform virtual physics experiments, walk through molecules, and inhabit worlds of their own making. The potential for educational VEs appears as limitless as a child's imagination.

Despite the potential of VEs as educational tools, little is known about how the system parameters which define a virtual environment impact a child trying to use the environment, what the impact of the parameters are on the child's ability to learn, or how the child's age changes the impact of the parameters. Most research involving children and VEs has focused on the ways in which VEs can be used as educational tools and on how children react to the VE. Current literature offers little besides anecdotal evidence as to the impact of various system parameters on a child's performance in an VE. Designers of VE applications targeted at children must rely on studies done with adults to guide their design decisions. The failure to fully understand how children differ from adults in their responses to VEs poses a serious obstacle to the design of effective learning environments for children.

The goal of the proposed research is to investigate the impact of varying one system parameter, FOV, on the performance of middle elementary schoolchildren and the incident of side-effects in that population in an immersive VE. The other goal of this research is to identify how, and if, middle elementary schoolchildren's responses to this environment differ from that the adult participants. This study is a first step in systematically assessing the impact of VE system parameters on children and assessing how the age of a child changes the impact of these parameters. Such knowledge will help VE system designers create more usable and effective VEs for children of all ages.

Procedures

Participants will be 36 7-9 year old children and 36 adults. Children will be recruited from the local area, and adults will be recruited from university. Participants will be recruited using 1) flyers placed at the university and in the local community and 2) e-mail messages submitted to local Blacksburg Electronic Village (BEV) newsgroups. The information content of the flyers and the e-mail messages will be identical, and will include a brief description of the experiment, the age groups being recruited, the time requirements of the experiment, the amount paid participants, and information on contacting the experimenter.

Each participant (or the adult accompanying a child participant) will fill out a consent form. If the participant is a child, he/she will be asked if he/she wishes to participate in the experiment. Next, each participant (or the adult accompanying a child participant) will fill out a pre-session questionnaire on the participant's present physical condition and a motion history questionnaire. Vision and balance will also tests will be performed. Vision will be assessed using the Bausch and Lomb® vision acuity test (F-3), and color vision will be assessed with the Cube Comparisons Tests (form S-2) from the Kit of Factor-Referenced Cognitive Tests. Balance stability will be assessed using the following postural tests: Stand-on-Nonpreferred-Leg and Stand-Heel-to-Toe. Only participants with in good physical condition, having no currently existing symptoms of motion sickness, a visual acuity of 20/40 or better, and normal color vision will continue with the study. If the participant fails to meet the vision requirements, no information about the nature of the defect will be given to the participant (or the adult accompanying a child participant) unless the participant (or the adult accompanying a child participant) specifically requests the information. Should such information be given, the participant (or the adult accompanying a child participant) will be cautioned that the experimenter is not an ophthalmologist and that an examination by an ophthalmologist is required to confirm the experimenter's findings.

After completing the pre-screening questionnaires and tests, participants (and his/her parent if participant is a child) will be introduced to the testing environment and undergo a ten minute training session with the VE equipment. During the training session, the use of the joystick for navigating and interacting with the VE will be demonstrated without the helmet mounted display (HMD). Then participants will be fitted into the HMD and the demonstrations will be repeated. Adults accompanying child participants will be given the option of trying out the equipment. Lastly, the participant will be asked to complete one basic navigation and one interaction task without the aid of the experimenter. The full experiment will begin after the participant has successfully completed the practice session tasks. Adults accompanying child participants will view the experiment from a waiting area equipped with a video-audio hookup which allows the adult to see and hear the child during the entire experimental session. The waiting area will be equipped with comfortable seating and a computer, which is loaded with games and web surfing software.

Participants will undergo approximately 30 minutes of navigation and interaction tasks in the VE. Each participant will be taught a specific route through a sequence of six rooms, each of which contains a distinctive landmark. After a learning criterion is achieved, the participant will then asked to reverse the route. Participants who require more than 10 route traversals to achieve the learning criteria will be removed from the study. While traversing the reversed route, the participant will be asked to 1) identify the landmark associated with the next room on the route, 2) make inferences as to what room was behind doors which had not been traversed when learning the route, and 3) point to obstructed objects that were previously viewed. The participant will then removed from the environment.

Participants will be carefully monitored for adverse side effects of immersion. Possible side effects include minor discomfort, blurred vision, disorientation, slight headaches, and nausea. Any participant experiencing adverse side-effects will be verbally reminded of their freedom to withdraw from the experiment. Adults that accompany child participants experiencing adverse side-effects will be reminded of their freedom to withdraw the child from the study.

After the VE session, the participant will remove the VE equipment and fill out the Post-Session Questionnaire to assess any side effects that may have developed from the VE session. The participant will also be asked to construct a model of the house out of small cardboard boxes representing the rooms. Additionally, the vision and balance tests will be repeated. Any subject who experiences any immersion side-effects will be required to stay a full hour after the VE session is completed. A comfortable waiting area will be provided for these individuals.

Risks and Benefits

There are some risks to the subject in this study. The nature and content of VE presents no inherent danger, unpleasant experiences, or emotional distress. However, different individuals may experience motion sickness-like side effects due to immersion into VE. Possible side effects include minor discomfort, blurred vision, disorientation, slight headaches, and nausea. Any symptoms should dissipate within one hour after the experiment. It is possible for some symptoms to appear and linger over the course of up to half a day following the experiment.

All subjects perform post-VE tasks which will allow the experimenter to monitor any possible side effects from the VE. Additionally, any subject that has reported any symptoms will be required to stay a full hour after the VE session is completed. A comfortable waiting area will be provided for these subjects. Subjects will be informed of the possibility of these risks and the length of time following the study that they may arise and persist. Adults subjects will be recommended not to do any extensive driving for at least three hours after the experimental session. Additionally, all subjects will be required to have a non-self-operated mode of transportation away from the laboratory.

This research is an initial step in determining how various VE system parameters impact children and how children's responses to the parameters differ from that of adults.   This study assesses the impact of varying one system parameter, FOV, on children's performance and the incidence of side-effects in an immersive VE. Such knowledge will help VE system designers create more usable and effective VEs for children.

Confidentiality / Anonymity

Participants will only be connected to their data by a participant number assigned by the experimenter. No record matching the participant number to the participant's name will be made. All raw data collected from this study will be kept behind the locked doors of the lab and offices of the Human Computer Interaction Laboratory in Whittemore Hall. Only the investigator and the faculty advisor will have access to the raw data. All written accounts of this work will identify data only with a participant number.

Informed Consent

A copy of the informed consent form has been attached.

Biographical Sketches

The graduate student investigator for this project is Faith McCreary. Faith McCreary received a B.A. degree in mathematics from Gannon University/Villa Maria College in 1982 and a M.S. degree in applied mathematics from Rennselaer Polytechnic Institute in 1983. She has been a graduate student in human factors engineering at Virginia Polytechnic Institute and State University since August 1995. She is currently working on an M.S. in the Human-Computer Interaction Laboratory.   In the past, she has worked as a human factors consultant and as a software engineer for the National Aerospace and Space Administration (NASA). Additionally, she has worked as an applied mathematician for Battelle Pacific Northwest Laboratories.   Her research interests include human-computer interaction, virtual environments, usability, and designing computer applications for children.

The faculty advisor for this project is Dr. Robert C. Williges. Robert C. Williges, Ph.D., is a Professor of Industrial and Systems Engineering, Professor of Psychology, and Professor of Computer Science at Virginia Tech. He received the MA and Ph.D. degrees in Engineering

Psychology from The Ohio State University and the AB Degree in Psychology from Wittenberg University. He is a Fellow of the Human Factors and Ergonomics Society and the American Psychology Association, and is a member of the Institute for Industrial Engineering and the Association for Computing Machinery.

He served as President of the Human Factors and Ergonomics Society, President of Division 21 of the American Psychological Association, Member of the Executive Council of the Human Factors and Ergonomics Society, Member-at-large of the Executive Council of Division 21 of the American Psychological Association, Member of the Publications Board of the Human Factors and Ergonomics Society, and Secretary-Treasurer of Division 21 of the American Psychological Association. In addition to these elected positions, he has served, on the following professional committees: the Highway Research Board Committee on Road User Characteristics, the Membership Committee of Division 21 of the American Psychological Association, the Executive Council of Division 21 of the American Psychological Association, the Chapter Affairs Committee of the Human Factors and Ergonomics Society, the US Air Force Task Force on Basic Research Needs, the Education Committee of the Human Factors and Ergonomics Society (Chairman), Human Factors and Ergonomics Society Representative at the International Ergonomics Association in Amsterdam, the Training and Education Committee of Division 21 American Psychological Association (Chairman), the Finance and Budget Committee of the Human Factors and Ergonomics Society, the Policy and Planning Committee of the Human Factors and Ergonomics Society (Chairman), the National Research Council Working Group on Simulation, the Army Science Board, and the National Research Council Committee on Human Factors. In 1989, he won both the Franklin V. Taylor Award from the American Psychological Association for outstanding contributions to the field of engineering psychology and the President's Career Achievement Award from the Human Factors and Ergonomics Society.

Dr. Williges has been the Editor, Associate Editor, and Member of the Editorial Board of *Human Factors*. He is also on the Editorial Board of the *International Journal of Man-Machine Studies*, and has served as an Advisory Editor of *PsycINFO* and *Psychological Abstracts*, a reviewer for the Engineering Psychology section of *Journal Supplement Abstract Service*, an occasional reviewer for the *American Journal of Psychology, Journal of Experimental Psychology, Journal of Applied Psychology, Behavioral Research Methods and Instrumentation, IEEE Transactions on Systems, Man, and Cybernetics, Ergonomics*, the Highway Research Board of the National Academy of Sciences, McGraw-Hill Publishers, and John Wiley and Sons. He has over 150 scientific publications including a book, book chapters, journal articles, proceedings papers, and technical reports. Dr. Williges has made over 125 technical presentations at national and international scientific meetings. He received the 1974 and the 1993 Jerome H. Ely Awards for the best papers published in *Human Factors*.

Dr. Williges directs the activities of the Human-Computer Interface Laboratory in ISE and the Usability Methods Research Laboratory in Computer Science at Virginia Tech. His three current research interests include developing methods for usability evaluation, designing computer-based assistive technology for computer users with disabilities, and improving computer-based information presentation.

APPENDIX B : INFORMED CONSENT FORMS

Informed Consent Form for Adult Participants

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Adult Participants of Investigative Projects

Title of Project: Adult-Child Differences in Route Learning in an Immersive Virtual Environment
as a Function of FOV

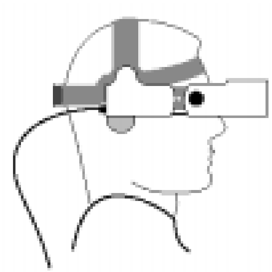
Investigator: Faith A. McCreary

I. The Purpose of this Research

The purpose of this research is to compare 1) adult and child performance in a virtual environment (VE) on a route learning task, and 2) the frequency and severity of side effects experienced by the adults and children as a result of immersion in the VE. Immersion involves replacing a user's environment with a computer-generated environment. It provides users with the illusion of actually being in the computer-generated environment and is achieved through the use of a helmet mounted display (HMD) and additional computer hardware.

II. Procedures

The virtual environment (VE) equipment will be a helmet mounted display (HMD) for presenting graphics, and a joystick for navigating and interacting with the VE. The HMD fits over the wearer's head in the manner shown below. Computer-generated graphical images will appear inside the helmet in front of the eyes. The HMD can be adjusted for the comfort of the wearer. Wires connect the HMD to the computer.



Your eligibility will be determined by a Pre-Session Side Effects Questionnaire. You will not be allowed to participate if you are not in good physical condition, are currently exhibiting symptoms of motion sickness, have a visual acuity of less than 20/40, or if your color vision is impaired. You will only be allowed to participate if you have a non-self-operated mode of transportation away from the laboratory. You will also be tested for vision and balance. Upon determining eligibility, you will complete a practice session with the VE equipment, and then begin a 30 minute session in the VE. Upon exiting the VE you will again be tested for vision and balance. Finally, another questionnaire will be filled out at the end of the session. Should you experience any side-effects as the result of your immersion in the VE, you will be required to remain in the laboratory for one hour following your last time of immersion.

The experiment will be conducted in a single session. You will complete the VE experimental tasks by following instructions from the experimenter. Experiment time should not exceed two hours.

The experiment is being held in the Human Computer Interaction Laboratory (HCIL) directed by Dr. Robert C. Williges. The HCIL is located in the Industrial and Systems Engineering Department, room 530 on the fifth floor of Whittemore Hall.

III. Risks

There are some risks to you in this study. The nature and content of VEs present no inherent danger, unpleasant experiences, or emotional distress. However, different individuals may experience motion sickness-like side effects due to immersion in VE. Possible side effects include minor discomfort, blurred vision, disorientation, slight headaches, and nausea. Any symptoms should dissipate within one hour after the experiment. It is possible for some symptoms to appear and linger over the course of up to half a day following the experiment. Should you experience any side-effects as the result of your immersion in the VE, you will be required to remain in the laboratory for one hour following your last time of immersion.

IV. Benefits of this Project

This research is a first step in determining how various VE system parameters impact children and how children's responses to the parameters differ from that of adults. This study assesses the impact of varying one system parameter, FOV, on children's performance and the incidence of side-effects in an immersive VE. Such knowledge will help VE system designers create more usable and effective VE environments for children.

While this research should yield benefits to the above stated goals, no promise or guarantee is offered. Participation in this project should not depend on a guarantee of benefits.

You may contact the investigators listed at the end of this consent form to inquire about the results and conclusions of this research.

V. Extent of Anonymity and Confidentiality

You will be identified only by a subject number in data analysis. No written results of this study will be traceable to a participant by name.

VI. Compensation

$5.00 per session.

VII. Freedom to Withdraw

You are free to withdraw from this study at any time without penalty. If you choose to withdraw, you will be compensated for the full session. You are free not to answer any questions or respond to any experimental situations that you choose without penalty.

There may be circumstances under which the investigator may determine that you should not continue the experiment. You will be still be compensated for the session.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University.

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I agree to undergo the procedures of this experiment as described above.

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project. A copy of this Informed Consent form will be provided to you.

______________________________ ______________________________

Signature Date

Should you have any questions about this research or its conduct, you may contact:

Faith A. McCreary
Investigator
(540) 231-8293

Dr. Robert C. Williges
Faculty Advisor
(540) 231-6270

H.T. Hurd
Director, Sponsored Programs
Research Division
(540) 231-5281

Informed Consent Form for Parent of Child Participant

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Parents of Child Participants of Investigative Projects

Title of Project: Adult-Child Differences in Route Learning in an Immersive Virtual Environment
as a Function of FOV

Investigator: Faith A. McCreary

I. The Purpose of this Research

The purpose of this research is to compare 1) adult and child performance in a virtual environment (VE) on a route learning task, and 2) the frequency and severity of side effects experienced by the adults and children as a result of immersion in the VE. Immersion involves replacing a user's environment with a computer-generated environment. It provides users with the illusion of actually being in the computer-generated environment and is achieved through the use of a helmet mounted display (HMD) and additional computer hardware.

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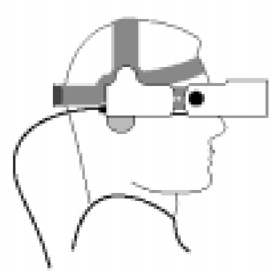
The virtual environment (VE) equipment will be a helmet mounted display (HMD) for presenting graphics, and a joystick for navigating and interacting with the VE. The HMD fits over the wearer's head in the manner shown below. Computer-generated graphical images will appear inside the helmet in front of the eyes. The HMD can be adjusted for the comfort of the wearer. Wires connect the HMD to the computer.



Your child's eligibility will be determined by a Pre-Session Side Effects Questionnaire. Your child will not be allowed to participate if he/she is not in good physical condition, is currently exhibiting symptoms of motion sickness, has a visual acuity of less than 20/40, or if his/her color vision is impaired. In order to participate, he/she must also have a non-self-operated mode of transportation away from the lab. He/she will also be tested for vision and balance. Upon determining eligibility, your child will complete a practice session with the VE equipment, and then begin a 30 minute session in the VE. Upon exiting the VE, the child will again be tested for vision and balance. Finally, another questionnaire will be filled out at the end of the session. Should your child experience any side-effects as the result of his/her immersion in the VE, you both will be required to remain in the laboratory for one hour following his/her last time of immersion.

The experiment will be conducted in a single session. Your child will complete the VE experimental tasks by following instructions from the experimenter. Experiment time should not exceed two hours. During the actual experiment, you will be asked to wait in the waiting area. The waiting area is equipped with a video-audio link which will allow you to both see and hear your child during the experiment.

The experiment is being held in the Human Computer Interaction Laboratory (HCIL) directed by Dr. Robert C. Williges. The HCIL is located in the Industrial and Systems Engineering Department, room 530 on the fifth floor of Whittemore Hall.

III. Risks

There are some risks to your child in this study. The nature and content of VE present no inherent danger, unpleasant experiences, or emotional distress. However, different individuals may experience motion sickness-like side effects due to immersion in VE. Possible side effects include minor discomfort, blurred vision, disorientation, slight headaches, and nausea. Any symptoms should dissipate within one hour after the experiment. It is possible for some symptoms to appear and linger over the course of up to half a day following the experiment. Should your child experience any immersion side-effects, both you and your child will be asked to remain in the waiting area for one hour following your child's last time of immersion.

IV. Benefits of this Project

This research is a first step in determining how various VE system parameters impact children and how children's responses to the parameters differ from that of adults. This study assesses the impact of varying one system parameter, FOV, on children's performance and the incidence of side-effects in an immersive VE. Such knowledge will help VE system designers create more usable and effective VE environments for children.

While this research should yield benefits to the above stated goals, no promise or guarantee is offered. Participation in this project should not depend on a guarantee of benefits.

You may contact the investigators listed at the end of this consent form to inquire about the results and conclusions of this research.

V. Extent of Anonymity and Confidentiality

Your child will be identified only by a subject number in data analysis. No written results of this study will be traceable to a participant by name.

VI. Compensation

$5.00 per session.

VII. Freedom to Withdraw

Your child is free to withdraw, or you are free to withdraw your child, from this study at any time without penalty. If he/she chooses to withdraw or is withdrawn, the child will be compensated for the entire session. The child is free not to answer any questions or respond to any experimental situations that he/she chooses without penalty.

There may be circumstances under which the investigator may determine that your child should not continue the experiment. The child will be compensated for the session.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University.

IX. Subject's Responsibilities

I voluntarily agree for my child to participate in this study. I agree for my child to undergo the procedures of this experiment as described above.

X. Parent's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for my child ____________________ to participate in this project.

If your child participates, you may withdraw your child, or your child can choose to withdraw, at any time without penalty. You agree that both you and your child will abide by the rules of this project. A copy of this Informed Consent form will be provided to you.

__________________________________ __________________________________

Signature Date

Should you have any questions about this research or its conduct, you may contact:

Faith A. McCreary
Investigator

(540) 552-4945

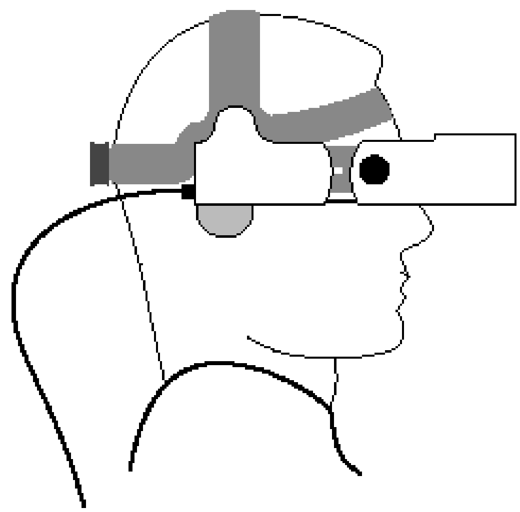
Dr. Robert C. Williges
Faculty Advisor
(540) 231-6270

H.T. Hurd
Director, Sponsored Programs
Research Division
(540) 231-5281

Child Assent Verbal Protocol

You are being asked to take part in an experiment involving virtual environments. Some people call virtual environments virtual reality. Virtual environments are a lot like computer games. The computer will make a fake world and you will use a joystick to make things happen in the world the computer makes. The experiment is not a test. It is a way for you to help me figure out how to make the virtual environment better.

The experiment will take about an hour. You will be paid $5.00 for taking part in the experiment. You will be asked to work on a computer while wearing a helmet mounted display (HMD). Here is what a person looks like while wearing an HMD.



The part of the HMD that covers your eyes is where the picture made by the computer will appear. The HMD is connected to the computer with wires. When you get done working with the computer, you will be asked some questions and you will be asked to do things like balance on one foot.

You don't have to participate in the experiment if you don't want to, and you can stop whenever you want. You will be paid the $5.00 even if you decide to stop.

Do you have any questions you want to ask me?

Do you want to be in the experiment?

APPENDIX C : PRE-SCREENING CHECKLIST

The following checklist will be used to determine participant eligibility. It will be administered over the phone to people expressing interest in participating in the study. If the potential participant is an adult, the questions will be addressed directly to the candidate; if the potential participant is a child, the questions will be addressed to the parent.

> Say: Thank you for your interest in my research. Because of the nature of the research, there are constraints on who may participate. Would you mind answering some questions so I can determine if [you are / your child is] eligible to participate.

1. [Are you 18 years old or older? / Is your child between 7 and 9 years of age?] (Yes)
2. [Are you / Is your child] color blind? (No)
3. [Do you / Does your child] have a personal history of epilepsy or seizures? (No)
4. Is [your / your child's] state of health good? (Yes)
5. Do [you / your child] have an uncorrected vision problem? (No)
6. Will [you / your child] have a non-self-operated mode of transportation away from the lab? In other words, [you / your child] will not be [driving or /] riding a bike or skateboard, away from the experimental session, right? (Yes)
7. For parents of child participants only : Will you be able to remain in the lab while your child participates in the study? (Yes)

If any of the responses did not match the ones in parentheses, the [person / person's child] can not participate; the caller will be told which question disqualified [them / their child] and will be thanked for their interest.

If all the responses match the ones in parentheses, the [person / person's child] can participate, and the caller will be scheduled for a session and told where to go for the experiment. Callers wishing to participate in the study, will be told the following:

> Please [do not take any alcohol or / allow your child to take any] drugs (especially decongestants, anti-histamines, sedatives, or tranquilizers) in the 24 hours preceding the session. [Your / Your child's] physical condition will be verified upon your arrival at the laboratory. If [you are / your child is] not in good physical condition, [you / your child] will not able to participate in the study. [Children must be accompanied by an adult, preferably their parent, and they cannot leave unless accompanied by an adult.] If you

need to reschedule your session for any reason (e.g. illness) or have any questions, please call me - Faith - at 552-4945. If I am not available when you call, please leave a message.

APPENDIX D: PRE-IMMERSION QUESTIONNAIRE

For Adult Participants

1. What is your age? _______ years _______ months

Please circle the appropriate responses for the following questions:

2. What is your gender? Male Female

3. Are you color blind? Yes No

4. Do you have a personal history of epilepsy or seizures? Yes No

5. Do you have a non-self-operated mode of transportation away from the experimental site? In other words, you will not be driving, walking, or riding a bike or , skateboard away from the session. Yes No

6. Are you in a good state of health? Yes No

If not, what is the nature of your illness (cold, flu, etc.)? ________________________________

____

7. How often do you experience motion sickness? Never Infrequently Frequently Always.

If you experience motion sickness, under what circumstance do you experience it? ___________

____

8. Which of the following medications and/or substances have you have used in the past 24 hours? Please circle all that apply.

(a) Alcohol
(b) Sedatives or tranquilizers
(c) Decongestants
(d) Anti-histamines
(e) Other
(f) None.

9. Do you enjoy using computers? Always Sometimes Rarely Never Not Applicable.

10. How often do you work with computers? Never Infrequently Frequently Always.

11. How often do you play computer or video games?
Never Infrequently Frequently Always.

11. How often do you experience virtual reality? Never Infrequently Frequently Always.

For Parents of Child Participants

1. What is your child's age? _______ years _______ months

Please circle the appropriate responses for the following questions:

2. What is your child's gender? Male Female

3. Is your child color blind? Yes No

4. Does your child have a personal history of epilepsy or seizures? Yes No

5. Does your child have a history of learning disabilities? Yes No

6. Can you remain in the lab while your child participates in the study? (Children must be accompanied by an adult, preferably their parent, and they cannot leave unless accompanied by an adult.) Yes No

7. Does your child have a non-self-operated mode of transportation away from the experimental site? In other words, your child will not be walking, or riding a bike or skateboard away from the session. Yes No

8. Is your child in a good state of health? Yes No

If not, what is the nature of your child's illness (cold, flu, etc.)? ______________________

____

7. How often does your child experience motion sickness? Never Infrequently Frequently Always.

If your child experiences motion sickness, under what circumstance does he/she experience it?
____
____

8. Which of the following medications has your child used in the past 24 hours? Please circle all that apply.

(a) Sedatives or tranquilizers
(b) Decongestants
(c) Anti-histamines
(d) Other
(e) None.

9. Does your child enjoy using computers?
   Always Sometimes Rarely Never Not Applicable.

10. How often does your child work with computers?
   Never Infrequently Frequently Always.

11. How often does your child play computer or video games?
   Never Infrequently Frequently Always

12. How often does your child experience virtual reality?
   Never Infrequently Frequently Always.

APPENDIX E: POST-IMMERSION QUESTIONNAIRE

Please circle the appropriate responses for the following questions:

1. Did you like virtual reality (VR)? Yes No
2. Was the picture in the helmet-mounted display hard to see? Yes No
3. Was the joystick hard to use? Yes No
4. Did you find VR interesting? Yes No
5. Was moving around in the environment easy? Yes No
6. Does your stomach hurt? Yes No
7. Does your head hurt? Yes No
8. Do you want to visit VR again? Yes No
9. Is your vision blurred? Yes No
10. Do you feel tired? Yes No
11. Do your eyes feel funny? Yes No
12. Was the helmet-mounted display heavy? Yes No
13. Is VR harder than using a computer? Yes No
14. Would you like to learn things in VR? Yes No
15. Do you feel dizzy? Yes No
16. Did the VR environment feel like a real place? Yes No
17. Did you get tangled in the wires when using the VR equipment? Yes No
18. Does any part of your body hurt? Yes No
19. Was VR boring? Yes No
20. Are you having difficulty concentrating? Yes No

21. Do your eyes feel tired? Yes No

22. Would you like to play a VR game? Yes No

23. Was the helmet-mounted display comfortable? Yes No

APPENDIX F : INTRODUCTION TO THE STUDY

The purpose of this study is to investigate the impact of varying FOV on the performance of adults and children, and to determine how, and if, children's responses to VEs differ from that of adults. The study is being conducted in the Human-Computer Interface Laboratory (HCIL), Department of Industrial and Systems Engineering (ISE) at Virginia Tech. The principal investigators are Faith McCreary, a graduate student in ISE, and Dr. R. C. Williges, co-director of the HCIL.

In this study you will be asked to learn a path through a virtual house, and then will be asked to perform tasks related to that path. The design of the virtual world is being evaluated, not you. Please do not be nervous about your performance on any of the tasks, just follow instructions and proceed in a manner that is comfortable for you.

You are being asked to spend approximately one hour in the HCIL participating in this experiment. After reading this introduction, you will be asked to fill out an informed consent form. If you agree to participate, your vision will be tested to ensure that you have normal visual acuity, color vision, and balance. A few measurements will also be taken to establish your virtual height.

Before the actual experimental session begins, you will be given further instruction about the tasks and what is expected of you as a participant. You will be given practice in using the VE equipment before beginning the entering the experimental environment.

You will be paid $5.00 for participating in this experiment. During the experiment, if for any reason you decide not to continue or if the experiment must be discontinued because of equipment failure, you will still be paid $5.00.

If you are still interested in participating in the study, please read and sign the informed consent form. Thank you for your participation.

APPENDIX G: IMAGES USED AS LANDMARKS IN VIRTUAL HOUSE

Figure 1. Blocks Used as Landmark for Room 1.

Figure 2. Bunny Used as Landmark for Room 2.

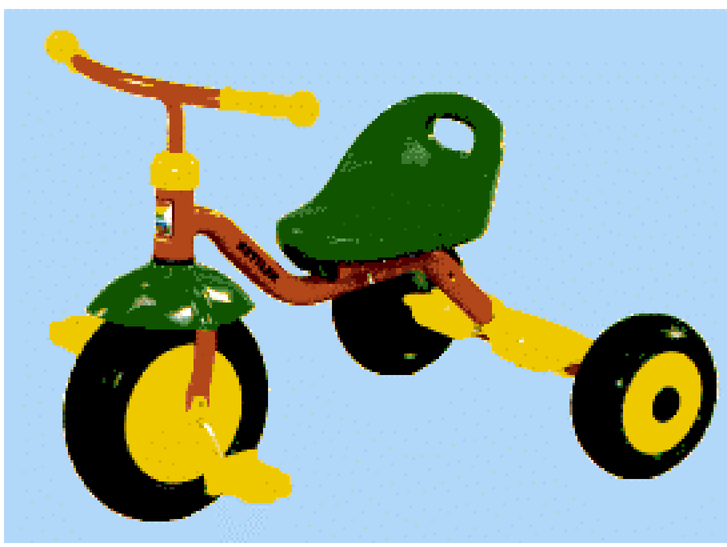


Figure 3. Tricycle Used as Landmark in Room 3.

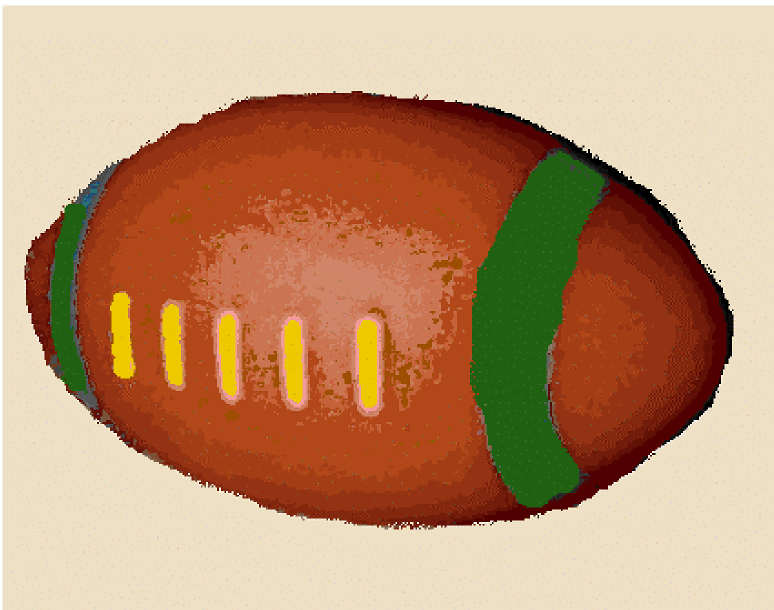
Figure 4. Truck Used as Landmark in Room 4.

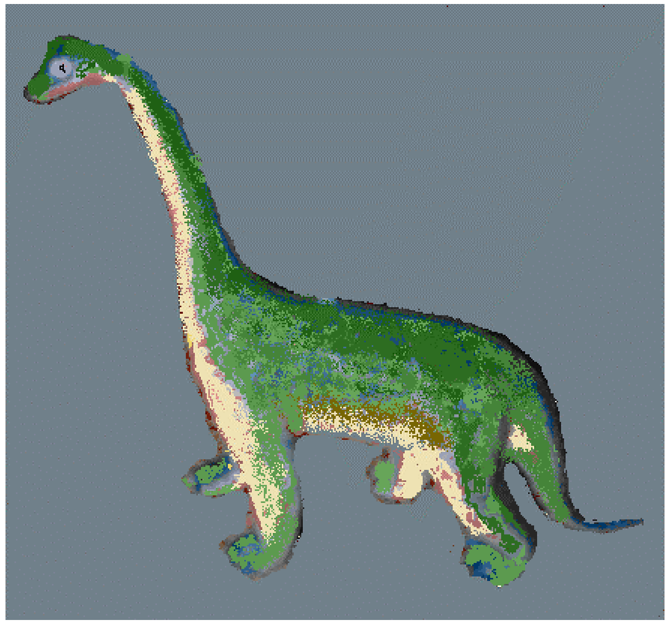
Figure 5. Teddy Bear Used as Landmark in Room 5.

Figure 6. Dolls Used as Landmark in Room 6.

APPENDIX H: ADDITIONAL IMAGES USED FOR LANDMARK RECOGNITION TEST

The following images (along with the images from Appendix G) will be presented to participants as part of the landmark recognition test. The order in which images will be presented to participants will be random and in no way related to their ordering in this document. Images are shown here at their actual size.





APPENDIX I : RAW DATA

Spatial Knowledge Data

Locomotion Efficiency

Table 1. Raw Collision Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Total Number of Collisions
30	7-9 year olds	Male	7.50	277
			7.92	214
			8.58	351
			8.75	14
			8.75	302
			8.92	32
			9.00	180
			9.75	1096
			9.83	553
		Female	7.25	10
			8.00	518
			8.00	206
			8.50	103
			8.50	446
			8.75	518
			8.83	110
			8.83	194
			9.42	242
	Adults	Male	20.42	482
			21.75	0
			21.83	88
			25.83	38
			27.83	82
			27.83	1
			40.50	120
			41.83	0
			52.58	61
		Female	19.50	91
			24.42	220
			30.50	4
			37.42	49
			37.50	149
			40.50	198
			41.92	414
			43.83	68
			44.00	61

Table 2. Raw Collision Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Total Number of Collisions
48	7-9 year olds	Male	7.80	120
			8.58	44
			8.75	156
			9.17	32
			9.25	13
			9.5	110
			9.67	157
			9.75	146
			9.99	137
		Female	7.08	366
			7.25	202
			7.92	597
			8.67	148
			9.08	155
			9.17	85
			9.25	87
			9.50	33
			9.83	31
	Adults	Male	20.75	21
			21.50	61
			21.75	24
			24.08	10
			24.50	7
			26.93	1
			29.75	3
			36.00	6
			49.42	21
		Female	20.42	60
			22.75	89
			22.83	50
			22.92	10
			27.75	18
			30.92	225
			32.00	105
			32.92	7
			36.60	19

Landmark Knowledge

Table 3. Raw Landmark Recognition Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Landmark Recognition Score
30	7-9 year olds	Male	7.50	20
			7.92	19
			8.58	19
			8.75	20
			8.75	20
			8.92	20
			9.00	20
			9.75	19
			9.83	20
		Female	7.25	19
			8.00	16
			8.00	20
			8.50	19
			8.50	20
			8.75	20
			8.83	20
			8.83	20
			9.42	18
	Adults	Male	20.42	19
			21.75	19
			21.83	19
			25.83	20
			27.83	20
			27.83	19
			40.50	19
			41.83	20
			52.58	20
		Female	19.50	20
			24.42	18
			30.50	20
			37.42	20
			37.50	19
			40.50	20
			41.92	20
			43.83	20
			44.00	20

Table 4. Raw Landmark Recognition Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Landmark Recognition Score
48	7-9 year olds	Male	7.80	20
			8.58	19
			8.75	19
			9.17	20
			9.25	19
			9.50	20
			9.67	20
			9.75	20
			9.99	20
		Female	7.08	28
			7.25	20
			7.92	19
			8.67	20
			9.08	19
			9.17	20
			9.25	20
			9.50	18
			9.83	20
	Adults	Male	20.75	19
			21.50	19
			21.75	20
			24.08	20
			24.50	19
			26.93	20
			29.75	20
			36.00	20
			49.42	19
		Female	20.42	19
			22.75	20
			22.83	19
			22.92	20
			27.75	20
			30.92	20
			32.00	19
			32.92	19
			36.60	20

Route Knowledge

Table 5. Raw Route Knowledge Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Route Metric	Landmark Prediction
30	7-9 year olds	Male	7.50	4	1
			7.92	3	4
			8.58	4	2
			8.75	0	5
			8.75	2	3
			8.92	3	3
			9.00	4	2
			9.75	2	4
			9.83	3	5
		Female	7.25	2	1
			8.00	3	4
			8.00	4	3
			8.50	3	3
			8.50	4	2
			8.75	2	2
			8.83	2	1
			8.83	5	2
			9.42	3	4
	Adults	Male	20.42	3	1
			21.75	6	6
			21.83	5	2
			25.83	4	3
			27.83	5	4
			27.83	5	5
			40.50	1	3
			41.83	3	2
			52.58	5	3
		Female	19.50	4	4
			24.42	4	4
			30.50	4	4
			37.42	5	5
			37.50	3	3
			40.50	2	4
			41.92	2	4
			43.83	2	2
			44.00	4	5

Table 6. Raw Route Knowledge Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Route Metric	Landmark Prediction
48	7-9 year olds	Male	7.80	5	5
			8.58	5	5
			8.75	5	4
			9.17	4	5
			9.25	6	5
			9.50	4	3
			9.67	5	4
			9.75	3	5
			9.99	5	6
		Female	7.08	3	4
			7.25	3	2
			7.92	6	3
			8.67	5	4
			9.08	5	4
			9.17	6	6
			9.25	3	3
			9.50	5	3
			9.83	4	4
	Adults	Male	20.75	6	6
			21.50	6	6
			21.75	6	5
			24.08	6	6
			24.50	4	5
			26.93	6	6
			29.75	5	6
			36.00	6	6
			49.42	4	4
		Female	20.42	5	4
			22.75	4	3
			22.83	6	6
			22.92	6	6
			27.75	5	6
			30.92	4	2
			32.00	4	6
			32.92	3	5
			36.60	6	5

Configuration Knowledge

Table 7. Raw Configuration Knowledge Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Spatial Inferences Score	Azimuth Error 1 (deg.)	Azimuth Error 2 (deg.)	Model Building Score
30	7-9 year olds	Male	7.50	0	114.22	-162.92	10
			7.92	2	83.41	-105.66	18
			8.58	1	71.91	36.54	14
			8.75	3	-132.68	-105.43	12
			8.75	0	15.87	40.31	19
			8.92	1	78.21	67.93	9
			9.00	1	42.34	2.93	10
			9.75	1	69.73	-102.08	21
			9.83	0	-62.74	-24.807	12
		Female	7.25	0	90.90	106.02	15
			8.00	0	-166.56	-76.14	20
			8.00	0	-38.95	-128.00	19.5
			8.50	0	97.22	95.97	8
			8.50	0	59.45	51.14	10
			8.75	0	100.25	66.09	14
			8.83	0	22.84	-2.59	11
			8.83	1	96.10	-31.72	9
			9.42	1	73.09	-8.31	13
	Adults	Male	20.42	2	-6.48	-14.57	28
			21.75	8	-28.35	-4.45	30
			21.83	4	-25.93	-25.93	18
			25.83	7	14.13	8.76	29.5
			27.83	8	-14.39	6.55	30
			27.83	7	-0.57	-25.02	28
			40.50	6	20.43	24.60	7
			41.83	2	22.08	-62.13	21
			52.58	2	112.61	-61.85	14
		Female	19.50	3	-67.01	0.01	15.5
			24.42	1	-31.57	-19.28	20
			30.50	4	65.72	19.80	28.5
			37.42	6	56.61	25.59	31
			37.50	4	141.59	-85.56	13
			40.50	1	-89.08	98.62	19
			41.92	2	47.91	-85.31	22
			43.83	1	52.54	-99.41	29.5
			44.00	0	63.90	12.11	19

Table 8. Raw Configuration Knowledge Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Spatial Inferences Score	Azimuth Error 1 (deg.)	Azimuth Error 2 (deg.)	Model Building Score
48	7-9 year olds	Male	7.80	2	6.71	46.53	15
			8.58	2	61.70	-18.57	27
			8.75	5	69.17	-82.42	10
			9.17	0	20.25	-8.09	29.5
			9.25	0	59.05	-16.77	18.5
			9.50	2	70.29	85.80	17
			9.67	2	157.37	123.33	22
			9.75	5	-13.19	25.86	21
			9.99	2	-18.56	-4.22	30.5
		Female	7.08	1	-143.92	78.11	28
			7.25	4	-127.95	6.05	28.5
			7.92	0	-54.20	-95.91	25
			8.67	0	99.25	-107.23	28
			9.08	4	-172.01	46.30	19
			9.17	3	69.92	24.82	18
			9.25	5	36.23	52.58	21
			9.50	5	52.34	45.69	12
			9.83	4	73.66	-0.65	21
	Adults	Male	20.75	8	-25.70	-26.61	31
			21.50	8	17.24	3.15	30.5
			21.75	8	2.43	-8.83	30
			24.08	8	2.50	3.86	29
			24.50	8	19.56	-18.07	29
			26.93	8	-26.31	-0.88	31
			29.75	8	2.74	-8.83	31
			36.00	8	-0.57	-2.91	30
			49.42	6	-1.92	-17.25	20
		Female	20.42	5	-26.03	-11.67	29
			22.75	8	4.03	61.19	23
			22.83	8	-17.51	-3.26	30
			22.92	8	-9.77	-1.46	31
			27.75	8	-11.94	2.61	31
			30.92	0	30.39	2.29	18
			32.00	6	0.35	-7.59	29.5
			32.92	5	-17.60	-100.83	23
			36.60	8	-5.75	21.74	28

Performance Speed

Table 9. Raw Performance Speed Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	In-Ve Task Time (seconds)	Model Building Time (seconds)
30	7-9 year olds	Male	7.50	607	144
			7.92	550	70
			8.58	1072	179
			8.75	628	197
			8.75	537	107
			8.92	559	337
			9.00	521	222
			9.75	802	93
			9.83	460	152
		Female	7.25	606	136
			8.00	601	183
			8.00	432	153
			8.50	461	152
			8.50	407	52
			8.75	829	152
			8.83	669	325
			8.83	1080	166
			9.42	467	191
	Adults	Male	20.42	484	30
			21.75	289	57
			21.83	706	133
			25.83	495	83
			27.83	490	100
			27.83	419	36
			40.50	511	45
			41.83	782	117
			52.58	635	98
		Female	19.50	416	188
			24.42	459	64
			30.50	795	252
			37.42	591	144
			37.50	694	95
			40.50	680	320
			41.92	595	318
			43.83	888	115
			44.00	397	92

Table 10. Raw Performance Speed Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	In-Ve Task Time (seconds)	Model Building Time (seconds)
48	7-9 year olds	Male	7.80	305	65
			8.58	539	167
			8.75	675	121
			9.17	540	259
			9.25	356	138
			9.50	526	95
			9.67	546	87
			9.75	483	102
			9.99	394	54
		Female	7.08	506	73
			7.25	601	153
			7.92	511	154
			8.67	336	118
			9.08	671	143
			9.17	392	121
			9.25	627	88
			9.50	594	78
			9.83	519	150
	Adults	Male	20.75	333	24
			21.50	318	77
			21.75	445	52
			24.08	451	26
			24.50	652	86
			26.93	334	36
			29.75	379	45
			36.00	373	43
			49.42	525	94
		Female	20.42	491	48
			22.75	509	91
			22.83	530	142
			22.92	331	39
			27.75	407	91
			30.92	762	127
			32.00	443	28
			32.92	589	138
			36.60	464	82

Subjective Data

Table 11. Raw Subjecitve Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Enjoyment Rating	Equipment Difficulties Rating	Immersion Side-effects Rating	Presence
30	7-9 year olds	Male	7.50	6	5	2	1
			7.92	6	3	3	0
			8.58	6	1	1	0
			8.75	6	1	0	1
			8.75	6	5	1	0
			8.92	6	3	2	1
			9.00	5	2	1	1
			9.75	6	0	1	1
			9.83	6	3	1	1
		Female	7.25	6	3	1	1
			8.00	5	5	7	1
			8.00	6	5	5	1
			8.50	3	5	6	0
			8.50	6	2	0	0
			8.75	6	5	4	0
			8.83	6	3	0	1
			8.83	6	1	0	1
			9.42	6	1	1	1
	Adults	Male	20.42	2	2	2	1
			21.75	5	1	0	0
			21.83	5	4	7	1
			25.83	6	4	1	0
			27.83	4	1	1	0
			27.83	6	1	0	1
			40.50	4	1	0	1
			41.83	5	1	0	0
			52.58	6	1	0	1
		Female	19.50	5	3	1	1
			24.42	5	3	4	0
			30.50	5	2	0	0
			37.42	4	3	1	0
			37.50	5	4	2	0
			40.50	4	6	0	0
			41.92	6	5	0	0
			43.83	5	4	0	0
			44.00	6	3	0	0

Table 12. Raw Subjecitve Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Enjoyment Rating	Equipment Difficulties Rating	Immersion Side-effects Rating	Presence
48	7-9 year olds	Male	7.80	6	4	0	1
			8.58	6	3	2	1
			8.75	6	0	0	1
			9.17	5	3	1	0
			9.25	6	1	0	0
			9.50	6	2	0	1
			9.67	6	2	3	1
			9.75	6	3	5	1
			9.99	6	2	3	0
		Female	7.08	5	6	5	1
			7.25	6	2	4	1
			7.92	6	3	1	1
			8.67	6	3	0	1
			9.08	6	5	4	0
			9.17	6	4	1	1
			9.25	6	3	2	1
			9.50	5	0	0	1
			9.83	6	4	0	1
	Adults	Male	20.75	5	3	2	0
			21.50	4	5	1	0
			21.75	6	1	1	1
			24.08	6	3	1	1
			24.50	6	1	0	0
			26.93	6	0	1	1
			29.75	5	3	0	0
			36.00	6	0	0	0
			49.42	6	0	0	1
		Female	20.42	6	2	1	0
			22.75	6	2	0	0
			22.83	4	3	5	1
			22.92	6	5	0	0
			27.75	5	1	0	1
			30.92	2	2	0	0
			32.00	6	2	1	1
			32.92	2	4	4	0
			36.60	6	3	2	1

Immersion Side-Effects Data

Table 13. Raw Immersion Side-Effects Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	SONL Score	SHT Score	Visaul Acuity Score	Color Vision Score
30	7-9 year olds	Male	7.50	-10	0	0	0
			7.92	0	0	0	0
			8.58	1	0	0	0
			8.75	0	0	0	0
			8.75	0	-6	0	-1
			8.92	0	0	-1	0
			9.00	12	5	0	0
			9.75	-9	-37	0	0
			9.83	0	0	-4	-3
		Female	7.25	-3	18	0	0
			8.00	-19	-12	-1	0
			8.00	0	0	-1	0
			8.50	-10	0	-1	0
			8.50	-14	0	1	0
			8.75	0	0	0	0
			8.83	0	0	0	0
			8.83	0	0	-1	0
			9.42	0	0	0	0
	Adults	Male	20.42	0	0	1	0
			21.75	0	0	1	0
			21.83	-8	1	0	0
			25.83	0	0	0	0
			27.83	0	0	0	0
			27.83	0	0	0	0
			40.50	0	0	1	0
			41.83	-6	0	0	0
			52.58	12	0	-2	0
		Female	19.50	0	-18	-1	0
			24.42	0	0	0	0
			30.50	0	0	3	0
			37.42	0	0	-1	0
			37.50	0	0	0	0
			40.50	0	0	0	0
			41.92	0	0	0	0
			43.83	0	0	0	0
			44.00	7	0	1	0

Table 14. Raw Immersion Side-Effects Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	SONL Score	SHT Score	Visaul Acuity Score	Color Vision Score
48	7-9 year olds	Male	7.80	0	0	1	1
			8.58	-6	0	1	0
			8.75	0	-18	1	0
			9.17	0	0	2	0
			9.25	0	0	1	0
			9.50	0	0	-1	0
			9.67	0	-20	0	0
			9.75	0	-12	0	1
			9.99	-9	0	0	0
		Female	7.08	-23	-42	1	0
			7.25	-18	-33	-1	-1
			7.92	3	2	-1	0
			8.67	-14	0	1	0
			9.08	-14	0	0	1
			9.17	0	0	0	0
			9.25	5	6	3	0
			9.50	-13	-12	-1	0
			9.83	-7	0	0	0
	Adults	Male	20.75	0	0	2	0
			21.50	0	0	0	0
			21.75	0	0	-1	0
			24.08	0	0	0	0
			24.50	0	0	4	0
			26.93	0	0	0	0
			29.75	0	0	1	0
			36.00	0	0	0	-1
			49.42	0	13	-2	0
		Female	20.42	0	0	0	0
			22.75	0	0	-1	0
			22.83	0	0	0	0
			22.92	0	0	0	0
			27.75	0	0	0	0
			30.92	0	0	-2	-1
			32.00	0	0	1	0
			32.92	0	0	1	0
			36.60	-3	-6	0	0

VE Break Data

Table 15. Raw Performance Speed Data for Lower FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Number of Breaks	Total Break Time (seconds)
30	7-9 year olds	Male	7.50	1	361
			7.92	1	62
			8.58	1	358
			8.75	1	287
			8.75	1	262
			8.92	1	126
			9.00	1	220
			9.75	1	556
			9.83	1	235
		Female	7.25	1	177
			8.00	4	641
			8.00	1	391
			8.50	1	308
			8.50	2	620
			8.75	0	0
			8.83	1	94
			8.83	2	325
			9.42	1	288
	Adults	Male	20.42	0	0
			21.75	0	0
			21.83	0	0
			25.83	0	0
			27.83	0	0
			27.83	0	0
			40.50	0	0
			41.83	0	0
			52.58	0	0
		Female	19.50	0	0
			24.42	0	0
			30.50	0	0
			37.42	0	0
			37.50	0	0
			40.50	0	0
			41.92	0	0
			43.83	1	607
			44.00	0	0

Table 16. Raw Performance Speed Data for Higher FOV Condition.

HFOV (deg.)	AGE	GENDER	Chronological Age (Years)	Number of Breaks	Total Break Time (seconds)
48	7-9 year olds	Male	7.80	1	318
			8.58	1	297
			8.75	4	1363
			9.17	1	304
			9.25	1	229
			9.50	1	238
			9.67	1	426
			9.75	1	878
			9.99	2	256
		Female	7.08	2	648
			7.25	2	810
			7.92	2	237
			8.67	0	0
			9.08	1	111
			9.17	0	0
			9.25	1	135
			9.50	1	401
			9.83	1	411
	Adults	Male	20.75	1	170
			21.50	0	0
			21.75	0	0
			24.08	0	0
			24.50	0	0
			26.93	0	0
			29.75	0	0
			36.00	0	0
			49.42	0	0
		Female	20.42	0	0
			22.75	0	0
			22.83	2	150
			22.92	0	0
			27.75	0	0
			30.92	0	0
			32.00	0	0
			32.92	0	0
			36.60	0	0

APPENDIX J : ADULT CHRONOLOGICAL AGE TREND PLOTS

This appendix contains plots of chronological age effects on those measures where AGE was a significant factor ($\alpha \leq 0.05$).

Spatial Knowledge

Locomotion Efficiency

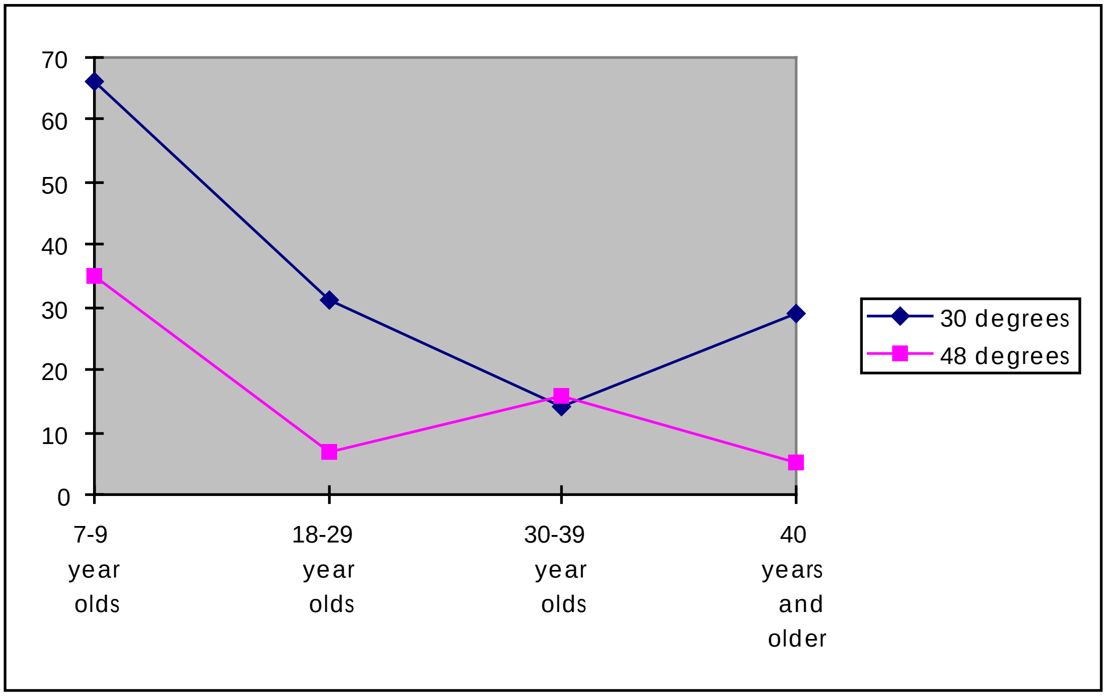


Figure 7. Impact of chronological age on the average number of collisions made during a 5-minute period.

Route Knowledge

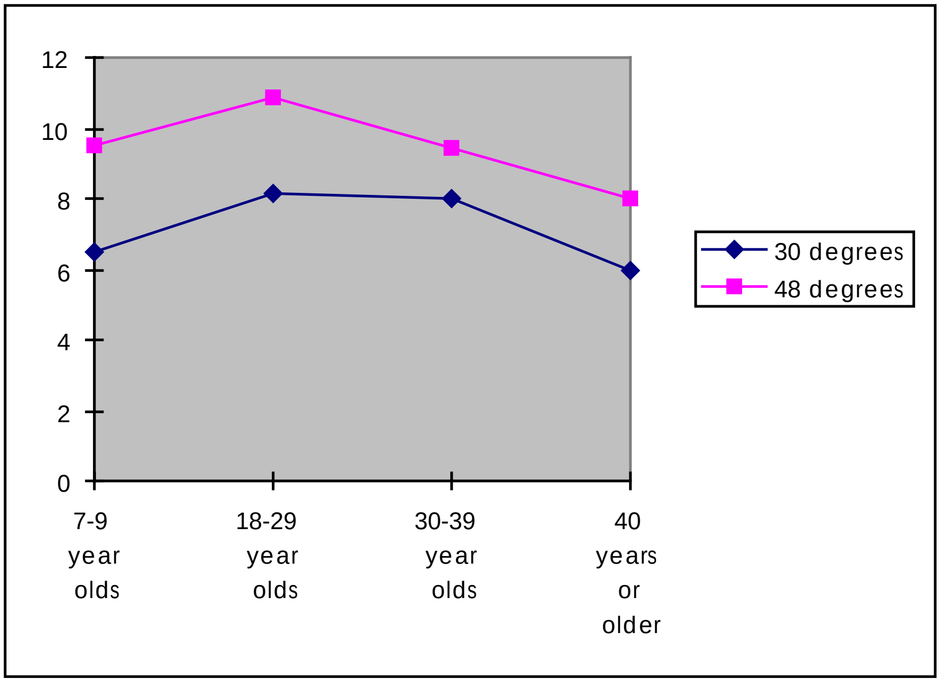


Figure 8. Impact of chronological age on mean composite route knowledge score.

Configuration Knowledge

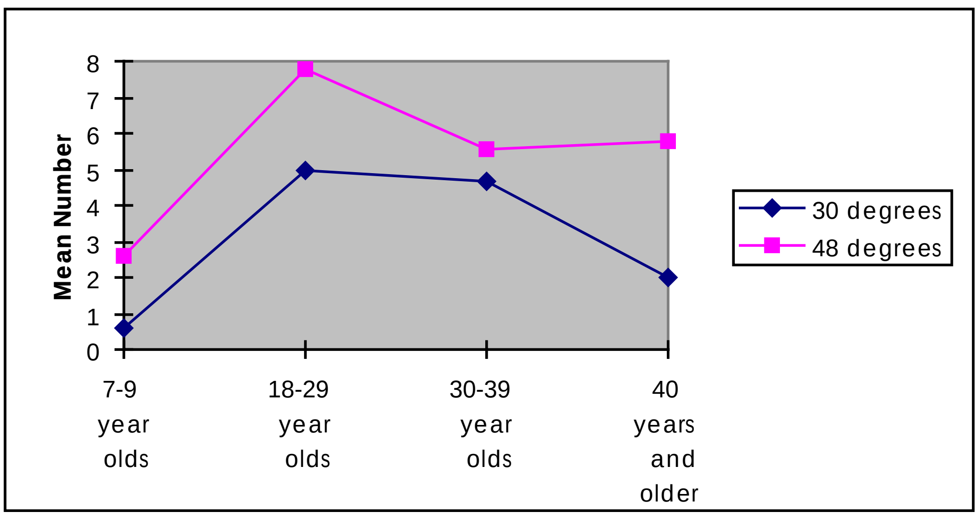


Figure 9. Impact of chronological age on the mean spatial inference score.

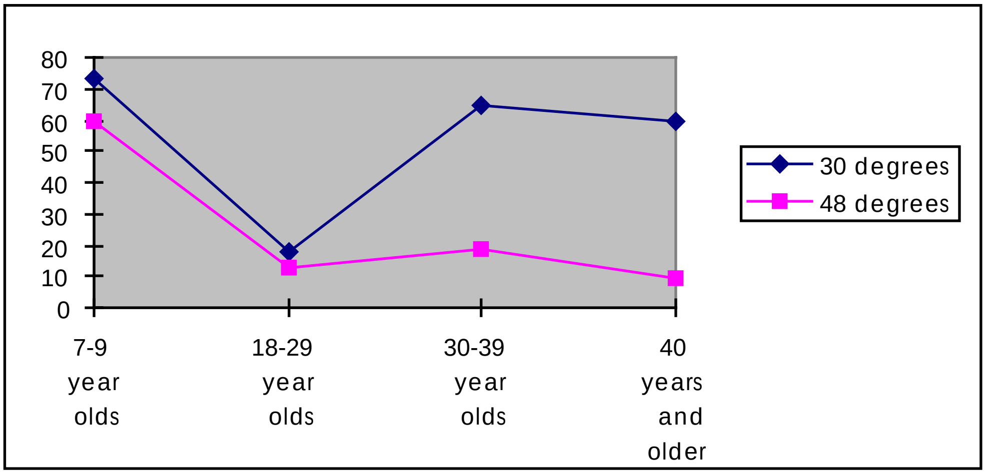


Figure 10. Impact of chronological age on mean absolute azimuth error.

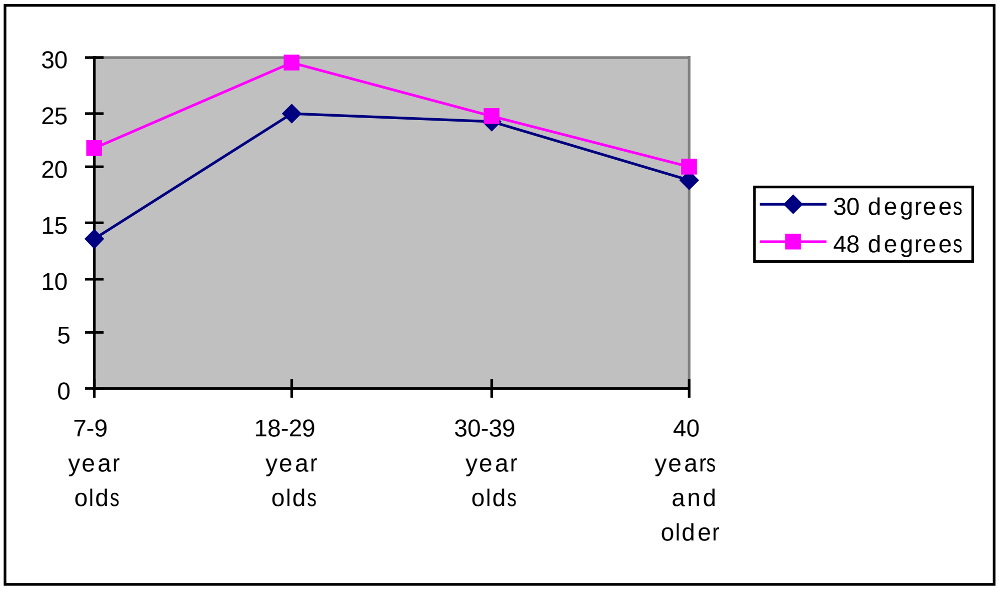


Figure 11. Impact of chronological age on mean building model score.

Performance Speed

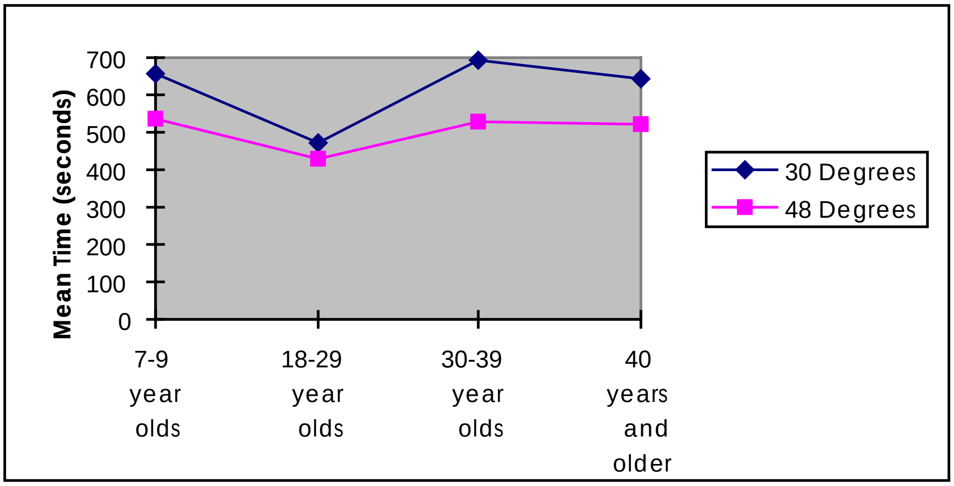


Figure 12. Impact of chronological age on the mean time to complete VE spatial tasks.

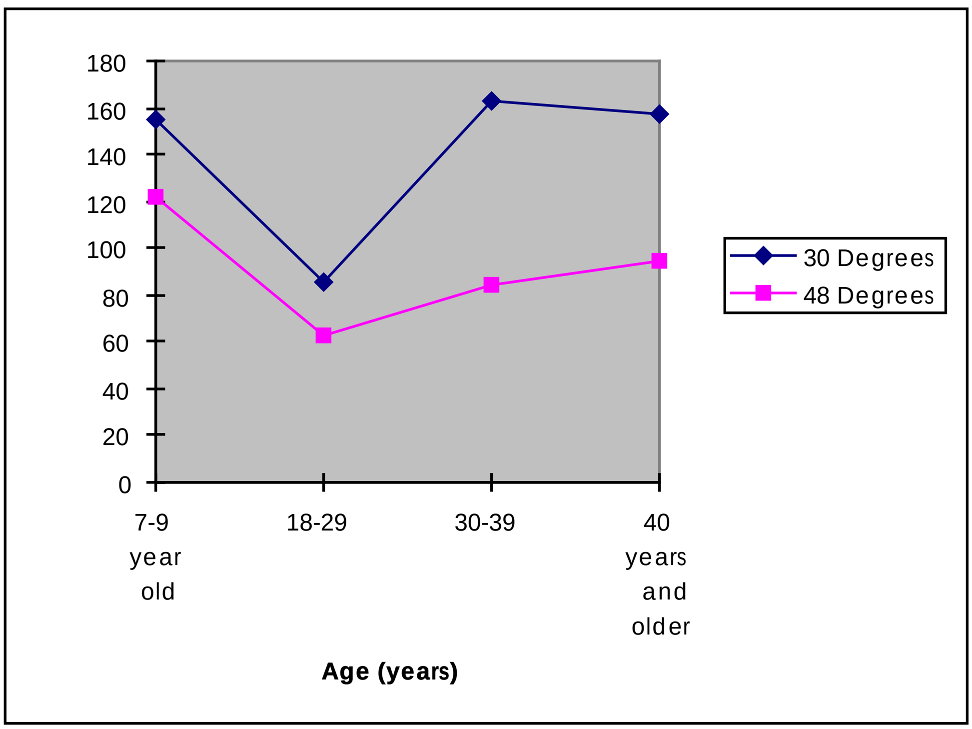


Figure 13. Impact of chronological age on mean model building time.

General Enjoyment

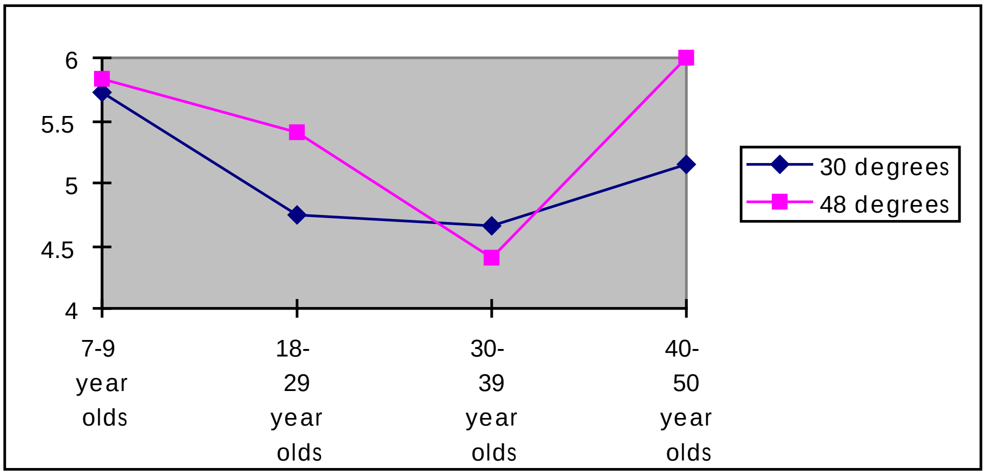


Figure 14. Impact of chronological age on general enjoyment score.

Immersion Side-effects

Balance Side-effects

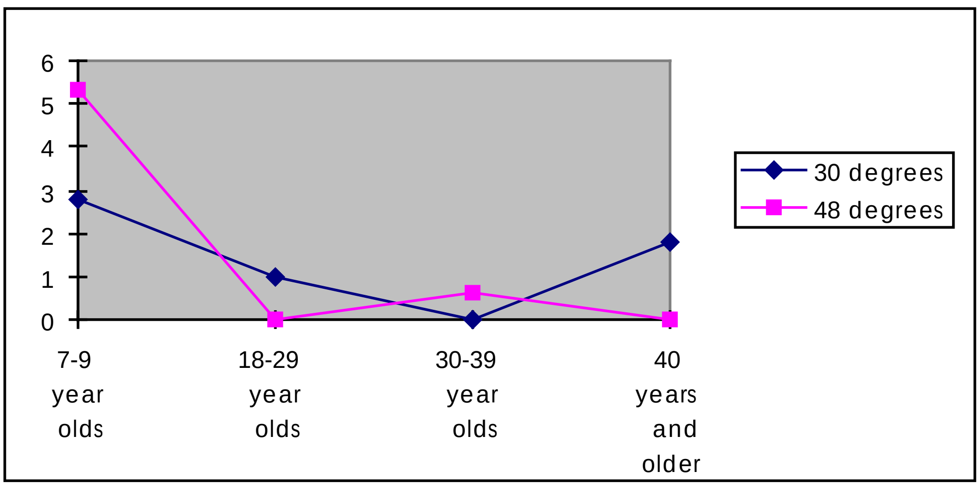


Figure 15. Effect of chronological age on the magnitude of SONL measure.

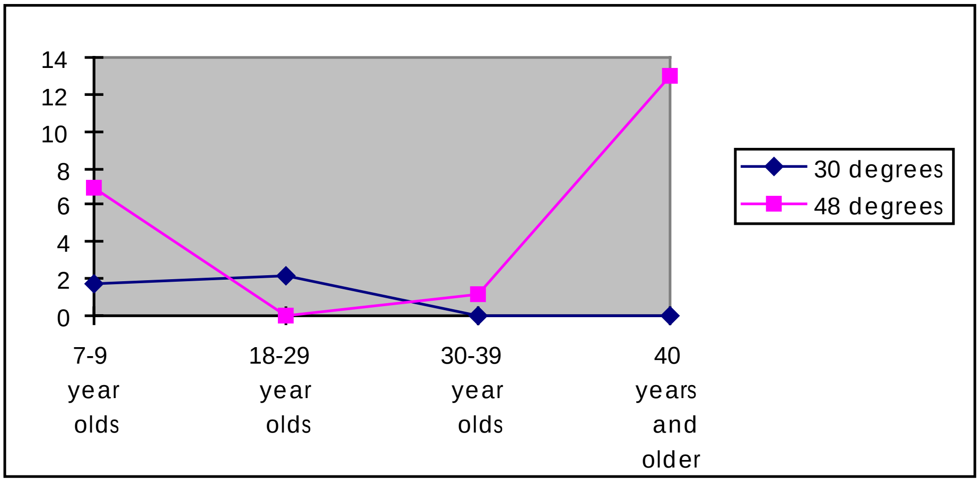


Figure 16. Effect of chronological age on magnitude of SHT score.

Break Taking

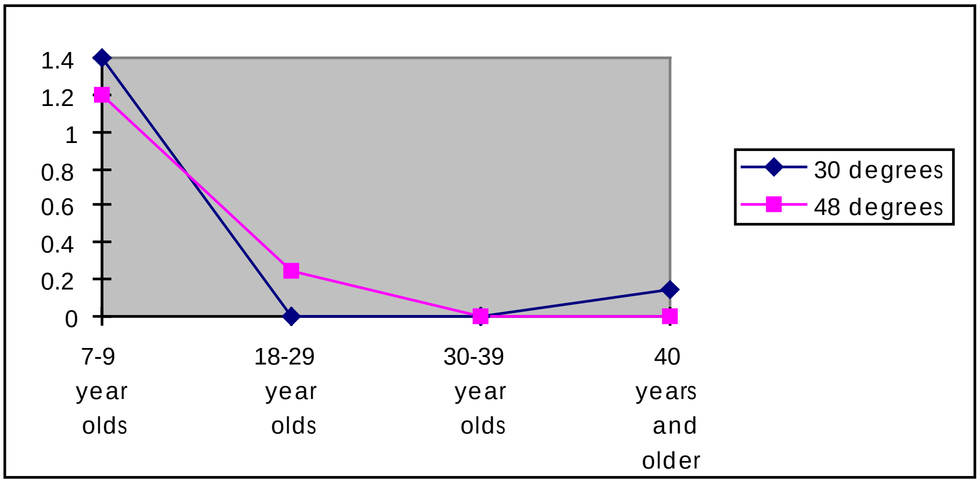


Figure 17. Effect of chronological age on the number of breaks.

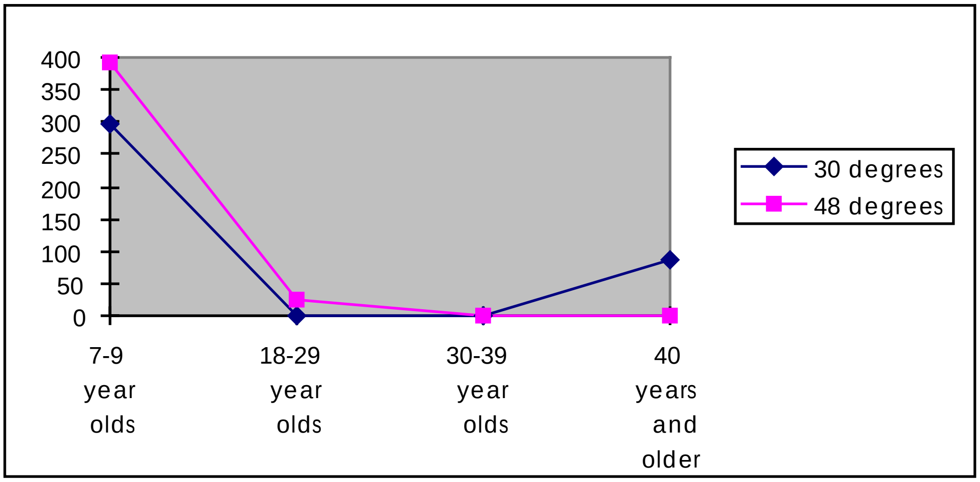


Figure 18. Impact of chronological age on break time.

APPENDIX K : POTENTIAL ADULT-CHILD DIFFERENCES IN PERFORMANCE AND PRESENCE AS A FUNCTION OF VE SYSTEM PARAMETERS

This appendix summarizes likely impact of VE system parameters and their impact on adult-child differences in performance and responses to VEs that were considered in the early stages of this research. This list should not be considered exhaustive.

Parameter	Impact on Presence		Impact on Performance	
	Adults	Children	Adults	Children
Input Device	• Widely accepted hypothesis that using familiar sensorimotor skills to manipulate virtual objects directly, e.g. dataglove, contributes to sense of presence.	• No experimental comparison in VEs.	• Locomotion and manipulation, but not tracking, tasks were sensitive to differences between a spaceball & joystick. (Lampton et. al, 1994)	• No experimental comparison in VEs. • Wands have been used with varying degrees of success with school age children. (Bricken and Bryne, 1993; Winn, 1996) • Datagloves used successfully in VE with 8-10 yrs. (Merickel, 1991) • 3-4 yrs had trouble with continuous control ⇒ overshoot problems; significantly better performance with discrete controls. (Strommen, 1993) • Ainge (1996) reported overshoot problems with 2nd graders in desktop VE. • Anecdotal evidence of young kids' problems with mice or other input devices which require a firm grasp of left/right. (Ainge, 1996). • Potential for

Parameter	Impact on Presence		Impact on Performance	
	Adults	Children	Adults	Children
				problems related to hand size.

Parameter	Impact on Presence		Impact on Performance	
	Adults	Children	Adults	Children
Field of View (FOV)	• Positive correlation. (Held & Durloch, 1991; Barfield and Weghorst, 1993; Psotka et al., 1993; Steuer, 1992; Zelter, 1992)	• No experimental studies.	• Positive correlation for visual search tasks. (Wells and Venturino, 1989; Piantanida et al., 1992) • Smaller FOV ⇒ underestimation of distances (Henry and Furness, 1993; Barfield and Rosenburg) • Larger ⇒ better spatial awareness. • No impact on walking speed. Rapid adaptation. (Cha, et al. 1992).	• No experimental studies. • Likely greater impact due to higher cognitive effort.
Head Tracking	• Anecdotal evidence (Heeter, 1992) • Mixed results (Sheridan, 1996; Held and Durlach, 1992) • Positive correlation (Hendrix, 1994)	• No experimental studies.	• No significant performance or preference differences but large amount of inter-subject variability. (Chung, 1992)	• No experimental studies.
Scene Update Rate	• Negative correlation. (Carr and England, 1995; Held and Durlach, 1991; Steuer, 1992; Waldern, 1993).	• No experimental studies.	• Negative correlation. (Held & Durlach, 1991) • Negative correlation with simulator sickness. • less than 12 hz results in illusionary motion or simulator sickness. (McKenna and Zeltzer, 1992)	• No experimental studies. • Anecdotal evidence that 2nd graders in a desktop VE had trouble discriminating self movement from object movement under a slow update rate. (Ainge, 1996)

Parameter	Impact on Presence		Impact on Performance	
	Adults	Children	Adults	Children
Level of Detail (impacts speed of simulation)	• Component of fidelty. (Zeltner, 1993; Carr & England; 1993.)		• Number of studies stress importance of regularly spaced texture, even surfaces to support accurate perception. (Stevens, 1992; Wolpert, 1993) • Tiles on floor particularly important. (Draper, 1995) • For object inspection and recognition, light and shadowing greater role than texture gradients. (Wickens, 1992)	• No experimental study in VEs. • 6 year olds and younger have more difficulty than older children and adults in perceiving exact characteristics of complex figures and inter-relationships. (Vernon, 1976; Piaget and Inhelder, 1969) • Irrelevant dimensions have higher performance impact on young children. (Jackson, Osler and Kofsky, 1969) • Age-related differences in use of monocular depth cues. 4yrs - 25%; 9yrs - 75%; adults - 90%. (Wilcox and Teghtsoonian, 1971; Hagan, 1972)
Resolution of the Display (trade-off between resolution and FOV)	• Positive correlation. (Barfield and Weghorst, 1993; Held and Durlach, 1992; Slater ans Usosh, 1993; Steuer, 1992; Sheridan, 1996; Zeltzer, 1992)		• Positive correlation on moderately demanding visual tasks. (Draper, 1995, Snyder, 1996) • Interferes with resolving details, orientation of objects, and object's velocity. (Pinatanida et al., 1992)	• Studies have shown younger children have a higher cognitive overhead in dealing with objects that are out of focus, likely extends to Ves (Mackworth and Bruner, 1970; Yendoviskaya, 1971).

Parameter	Impact on Presence		Impact on Performance	
	Adults	Children	Adults	Children
Virtual Body	• Nothing conclusive. • Anecdotal evidence. (Heeter, 1992) • Full body representation significantly higher than 3d arrow. (Slater and Usosh, 1992) • Identification with representation critical. • Potential for effect to be lessened by small FOV.	• Some younger children assume that the lack of body implies they are dead. (Grove, 1995)	• Perception of VE scale is function of VB size. (Caird, 1994) • Virtual body not significant. Subjects relied more on other visual cues, e.g. tiled floor. (Draper, 1995)	• Lack of a visible virtual body can make object collision very disruptive to performance of 8-10 yrs; note adults in same desktop VE had no problems. (Grove, 1995) • Anecdotal evidence from 2nd graders in a desktop VE found that collision control made navigating the environment substantially more difficult. (Ainge, 1996)
Stereopsis	• Positive correlation (Barfield and Weghorst, 1993 Carr and England, 1993; Hendrix, 1996)	• No experimental study.	• Positive correlation for complex or unfamiliar imagery (Merritt, 1988), and difficult tasks (Arthur & Booth, 1993; Reinhart et al., 1990; Zenyuh et al., 1988); mixed results for others (Ehrlich and Singer, 1994).	• No experimental study in VEs. • Definite benefit to young children as a means of clarifying and sharpening the ability to analyze perceived space. (Dorety, 1977)

VITA

Faith McCreary

EXPERIENCE

1983 - Present **NASA / Jet Propulsion Laboratory, Pasadena, CA**

Primary responsibilities include:

Fall 1996-Present Educational leave of absence.
Pursuing graduate degrees in Industrial and Systems Engineering, Virginia Polytechnic Institute and State University. Human Factors option area. Researching adult-child performance differences in immersive virtual environments.

Summer 1996 Human Factors Engineer, Enterprise Tool Service (ETS).
Primary responsibility for the usability of the prototype ETS system and associated website. Usability testing, heuristic evaluation, and ethnographic methods were used to evaluate prototype system; developed usability metrics for system. Re-designed system interface using a user-centered design approach.

Fall 1995 - Spring 1996 Educational leave of absence.
Pursuing graduate degrees in Industrial and Systems Engineering, Virginia Polytechnic Institute and State University. Human Factors option area. Class projects included design and prototyping of a volunteer recruitment website for the Virginia Cooperative Extension, and usability evaluation of a commercial information manager.

1993 - Summer 1995 Lead, Navigation Data Systems Development, Space Systems and Navigation Technology Development, Advanced Technology Program, Office of Telecommunications and Data Acquisition.
Primary responsibility for the technical direction of navigation information systems development.

1983 - Summer 1995 Software engineer, Navigation System Section.
Design, implement, and maintain orbit determination and trajectory analysis software for flight projects. Responsible for the design and development of both user and programmer documentation for software set. Additional duties related to re-engineering legacy systems in a TQM environment. Activities include creation of tools to simplify development, documentation, and maintenance of software; development of coding standards; bench marking; and general process improvement. Focus of these efforts: usability engineering, design of on-line hypertext documentation, process automation, and visual programming.

Additional responsibilities include:

1994-Summer 1995 Lead, multi-disciplinary team re-engineering spacecraft data conditioning system. Activities included ethnographic workflow analysis and task analysis of current system, redesigning work practices to increase reliability and robustness, and designing groupware to support revised process. Participatory, scenario-based design approach.

1993 - Summer 1994 Lead, multi-disciplinary team designing suite of X Windows graphical user interfaces for navigation software system. User-centered design approach. Coordinated and conducted usability tests.

1992 -Summer 1995 Provide software support for planetary ephemeris development and technical support for international user community. Responsibilities include development and maintenance of on-line user documentation.

1989-1990 Developed readable, reasonable coding standards: "FORTRAN Programming Standards and Guidelines for the Space Flight Operations Center", and "The Deep Space Network Coding Guide" for the Office of Telecommunications and Data Acquisition.

1984-1988 Designed and implemented simulation software for atmospheric braking techniques of interplanetary spacecraft.

1982-1983 **Rennselaer Polytechnic Institute, Troy, NY**
Graduate Teaching Assistant, Mathematics Department.

1982 **Battelle Pacific Northwest Laboratories, Richland, WA**
Northwest College and University Association for Science Fellow, Applied Mathematician. Developed mathematical model of a cylinder exposed to an uniform electric field, developed associated simulation software, and verified results experimentally.

EDUCATION

1982-1983 **Rennselaer Polytechnic Institute, Troy, NY**
M.S. in Applied Mathematics.

1978-1982 **Gannon University / Villa Maria College, Erie, PA**
B.A. in Mathematics.