DEVELOPMENT OF AN ANAGLYPHIC COMPUTER PROGRAM FOR AMBLYOPIC ANTI-SUPPRESSION VISION THERAPY

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ABSTRACT

For over three decades video displays have been recognized as a potentially innovative and superior way to perform anti-suppression vision therapy for amblyopia. Despite this, very little progress has been made in developing programs to provide this invaluable need, and what programs do exist are very expensive, creating a financial burden on the practitioners that use them as well as their patients. Indeed, due to this cost many optometrists do not even take advantage of the software, and the patients of those that do often cannot afford to purchase it, causing many to miss out on a very powerful form of therapy. It is the goal of this project to help close this gap between need and accessibility with the development of a computer program to perform the basic anti-suppression tasks necessary for this form of therapy. This program could be freely distributed to practitioners and patients alike, providing capability for both therapy and, eventually, qualitative monitoring of improvement. The program's design makes use of anaglyphic glasses while displaying images of appropriate colors for cancellation. The images are of a variable size to adjust the difficulty level of the therapy.

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INTRODUCTION

Amblyopia, and the suppression entailed, has few treatment options presently available. Forcing the use of the amblyopic eye through patching and atropine penalization is the primary means of therapy, and has been shown to be very effective,[1-4] but is not without its faults. Patching is only effective if the patient and, when appropriate, their parents are compliant with the therapy. All too often, however, this is not the case. Compliance issues with patching arise from many causes, including confusion with instructions, not seeing clinic staff as authoritative, slow or no immediate improvement, social persecution, and educational impediment.[5] Atropine penalization overcomes many of these downfalls and is as effective as patching, as well as better accepted by the patient,[1] which likely makes it more effective in reality. However, it is not always an appropriate treatment. One such example is when the good eye, even fully cyclopleged by means of atropine, still maintains a better image than the amblyopic eye. Nonetheless, patching and penalization therapy are important treatment methods that when done properly can result in dramatic improvement.

Anti-suppression therapy, by forcing the use of the amblyopic eye as well as the use of the good eye to accomplish whatever task is being attempted, accomplishes the same thing as patching in a different way. It is also highly effective, at both improving the fusion of the two eyes as well as, in turn, the acuity of the amblyopic eye.[4,6] It has even shown success in cases where occlusion therapy failed outright or due to patient refusal to comply.[7,8] Anti-suppression therapy has many of the same problems as patching; However, patching alone will not necessarily convince the brain to stop suppressing. As mentioned, anti-suppression not only accomplishes the acuity improvement achieved through patching, but it has the added benefit of turning a monocular system into a binocular one, which greatly enhances the visual system's tendency to rely on, and therefore enhance the image quality of, the amblyopic eye. It therefore achieves two goals which reinforce each other.

Since it is well-proven these therapies work well when properly performed, and it is known compliance is low and the success of the treatment consequently suffers, the issue, then, is how to increase compliance. The key to this is to do proper education on the condition and the therapy, and to make the therapy more enjoyable so as to make the patient more willing and, ideally, even eager to do it. Presently, there are many forms of anti-suppression therapy, which adds variety to allow the patient to do tasks which they find enjoyable as well as mix things up to keep the therapy from getting too redundant. These include red-green activities such as mazes, flashlights, playing cards, word/number searches, GTVT charts, pegboard games, a ball and cup game, Padula's fusion cubes, tracings, the pegboard rotator, and more.

In addition, there are computer programs available which make use of red-green, red-cyan, and polarized glasses. These provide a wide array of available activities. This is possibly the most crucial advantage of computer therapy as the assortment and, ideally, entertaining nature of the activities increases the likelihood the patient will enjoy, and therefore do, their therapy. No therapy, regardless of how effective, is any good if the patient is noncompliant with it. Computer therapy has many benefits besides the variety, however. Unlike other therapies, it allows for quickly and easily changing the difficulty throughout the treatment process and, perhaps more importantly, can even adjust automatically based upon the patient's performance. Furthermore, it can track their performance, allowing the patient and doctor to monitor their progress. This is beneficial to the patient by providing them an opportunity to clearly see any improvements that are being made, making the therapy more rewarding and giving them encouragement to keep working. It's also very useful for the doctor, in that it provides excellent data for tracking any improvements as well as allowing them to monitor patients' compliance with the therapy. Yet another advantage of computer therapy is its portability. It takes no physical space, and can be taken anywhere with the patient on a laptop, a tablet, or even a phone, without actually requiring the patient to bring anything additional with them other than their anaglyphic or Polaroid glasses. Patients could even do therapy during their daily commute when taking public transportation, during their lunch break at work, or on the school bus. Finally, while often not the case, computer therapy can be extremely cheap. If a software program was made to provide the therapy, and was offered for free, the only cost to the doctor and patient would be for a pair of glasses and perhaps a cheap computer in the rare instance the patient doesn't already own one.

This is where the problem lies: Of the few presently available computer therapy programs, almost all are quite expensive. They cost a large amount of money for a program that provides a limited range of therapy, with multiple programs at these high prices required to cover the spectrum of treatment. Another option is to pay a smaller fee for a certain number of uses, but with the necessary treatment sessions often required this would add up to still be quite expensive. This creates a financial burden on the doctor by requiring a fairly substantial investment to stock the software and, of course, the patient, who has to pay the cost in the end for the use of it. This results in many practitioners and patients simply not taking advantage of this excellent resource. Video displays have long been recognized as having the potential to form a new era of vision therapy, and computer therapy has come leaps and bounds since the first attempts and continues to be tested to its limits and improved upon, with very promising results.[7-10] Unfortunately, with all the work that has been done in the field as far as making excellent programs that work very well, little has been done to make them accessible to everyone. As present, there appears to be only one free anti-suppression program available, a red-blue solitaire card game that is actually the result of a vision therapy patient modifying a pre-existing game to allow for cancellation.

It is therefore the purpose of this project to create a proof of concept program to show that with some programming knowledge and time, a decent application that can provide at least the more basic vision therapy requirements can be made, free to any and all who need it. Ideally, this program will not only accomplish that goal, but will do so in a way that makes using it fun, challenging, and informative. The initial focus of this program is anti-suppression therapy, but the intent is to demonstrate the potential for a variety of activities ranging from visual memory to oculomotor to vergences.

METHODS

This program was written in VB.NET (Visual Basic) 2010. This language was chosen for its relative simplicity and its capability of performing the required tasks. Furthermore, the option is available to port it to other languages, such as C++ or Java for cross-platform compatibility, i.e. the ability to run it on non-Windows computers. It could even be turned into a mobile app, something that is planned for the future.

The program currently has just one mode, an anti-suppression arrows game in which arrows of two colors, each visible by only one eye when wearing the appropriate glasses, are displayed on the screen. The user then presses the corresponding arrows on their keyboard to indicate what they think they see, and the program unobtrusively responds informing them if their answer is correct or incorrect. After a user-selected length of time passes, the program ends the game and announces their score, consisting of how many correct, incorrect, and total responses they gave for each eye's images and for all images combined, how many arrows they responded to per minute, and suggesting an increase, decrease, or no change in difficulty based on their performance. The is done if the user correctly responds to both colors more than 80 percent of the time, either color less than 60 percent of the time, or both colors more than 60 percent of the time but at least one 80 percent or less of the time, respectively. The game currently limits the choice of glasses to red/blue (or blue/red in the event the lenses are backwards from the standard design) for technical reasons, as these colors have shown in testing to cancel much more completely and more consistently across various screens. The user can also select the size and number of arrows as well as whether to have the arrows flash for tachistoscopic training. Currently, there is also an option to have the arrows disappear as they're responded to, though this functionality will likely be replaced in the future with a different method. A pause function has also been added to allow for unplanned distractions. While paused, the arrows are hidden so as to not allow cheating.

RESULTS

This game requires both eyes to work together to see the arrows so the user can accurately and quickly respond to them, particularly if the flash option is used. The user can start with larger and fewer arrows displayed for a longer period of time, working their way toward smaller arrows of increasing number and decreasing display time. It allows for a relatively fun, interactive way to do anti-suppression therapy and, in the future, to track progress for both the patient and the doctor. This will also help deal with compliance issues, or at the very least make it clear to the doctor in cases of noncompliance the reason for the therapy's ineffectiveness. In providing a free and entertaining way of doing therapy, this program has the potential to accomplish the goal originally set forth.

DISCUSSION

The game in its current state, with only a single function, shows much promise. As it stands, it can be used as a basic anti-suppression trainer. With time and further development, it can become much more. The future of the program holds many potential promises. There are numerous plans for additions and modifications to it. One of the most important is the ability to track progress, displaying it to the patient and doctor in a meaningful way. This would include the ability to handle outliers; e.g. if the patient gets distracted and quits playing halfway through without pausing, it would be a statistical anomaly and the results should be discarded. Additionally, a mode to have the arrows jump around randomly to work on saccades is planned, as well as the ability to use numbers and letters. The implementation of red-green may be included in a future version; however, it is likely the higher prevalence of red-green glasses will not justify the use of an inferior color scheme, particularly considering the low cost of red-blue glasses. Some changes will be made, such as what was mentioned earlier, where the current method of notifying the user if their input was correct or incorrect and the option to remove the arrows as they're responded to will be combined into one feature. The flashing feature will also be improved upon. Other options will be added, as will the ability to save and load a particular combination of options. Quantification of the arrow sizes for standardization based on monitor pixel pitch (or dots per inch) is in consideration but likely would be neither feasible nor necessary. The parameters for suggesting to the patient how to adjust the difficulty need further refinement, including taking into account their speed as well as accuracy. Other games that are planned for possible development and inclusion in this program are having random numbers and/or letters displayed, either in place or randomly around the screen, and requiring the user to press a key every time they see a specific one; a word search game; a game of one or more moving balls of different colors which require interaction with the mouse; mazes; random dot stereogram fusion exercises; and more.

At present, this program does suffer from some weaknesses, the most obvious of which is that it is incomplete and lacking many features. Probably the single most significant limitation is that there is a possibility the colors won't properly cancel on all displays due either to the display's or graphics unit's abilities or settings. In trying to avoid this issue, the colors selected for the program were chosen due to their consistent and effective cancellation on several different displays, a requirement not so easily met with red-green glasses, hence their absence in the current iteration of the program, and possibly future ones as well. Even so, there is no guarantee that when a patient runs the program on their computer or other device the display settings will be properly configured, thereby possibly resulting in failure to properly cancel. Unfortunately, no method of ensuring cancellation was conceived of, and it is possible it cannot be done. To try and deal with this, the program will in later versions remind the patient when they run it to make sure the colors cancel appropriately before playing. In the end, most if not all therapies share a common drawback: Relying on the patient to perform them properly. Another limitation is that the images used by the program, such as the arrows, can be modified by the user. This can be a good thing, allowing them to tweak the colors if necessary to work on their display, but it could also be a bad thing by allowing them to change the colors so they don't work or change the names of the files. However, this is a problem with many computer programs, and it is expected the user will not do these things. It is a possibility that future versions will incorporate the images into the application file itself or, better still, the application will create them as needed. Finally, the program presently suffers from the arrow pictures loading slowly when the game is first started; this will need to be fixed in the future through a modification of the code or possibly through the embedding of the images in the program.

Even with these limitations, this program can be very useful to those seeking a basic anti-suppression activity without wanting to pay the premium fees for other programs. Once these are dealt with, and more features are added, this program should have no problem taking the place of the currently available expensive programs, and that is the hope. Furthermore, it is the intent to release the program under an open license, most likely a copyleft license such as the GNU GPL (General Public License). This will allow others to contribute to the program, increasing its capabilities while continuing to be free.

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