Rowing against the current – European optometry getting closer in times of social distancing

Across Europe, education and clinical practice in optometry remains heterogeneous. In some European countries, optometry is a fully recognised profession and a well-established academic discipline whereas in others further developments are urgently needed. For the foreseeable future collaborative projects at associative and academic levels will occur between different countries to develop optometry as a profession. These efforts will expand the possibilities to share knowledge and expertise and will lead to further and faster development of the field of optometry allowing optometrists to provide competent eye health and vision care required by patients everywhere. At the beginning of 2020 one of these long-term highly promising projects was initiated when the Italian Optometric Society, named SOPTI, decided to join The Norwegian Association of Optometry (NOF) to support a project initiated in 2008 – The Scandinavian Journal of Optometry and Vision Sciences (SJOVS). In 2020 SOPTI became a joint owner of the journal and Fabrizio Zeri was handpicked to join the group of editors. This "joint venture" between the two associations and SJOVS will allow the promotion of the journal and will create new pathways and opportunities for the Italian optometric community that should consider SJOVS their new scientific platform for readers and authors.

This expanding European project has developed and will continue to thrive through utilization of digital communication despite restrictions imposed by COVID-19 at the beginning of 2020 leading to the dramatic and almost unthinkable closure of European borders. For now, two important European countries have joined in a common enterprise to empower the scientific relationship between their optometrists and researchers; hopefully, other countries and associations will follow in the near future. We anticipate a bright future for the world, for Europe and for optometry. Now, as in the past, human solidarity and intelligence will find solutions for the current crisis. We, the editors of SJOVS, with the support of the professional associations wish the very best for the European optometric community, and we are looking forward to receiving contributions from you to our journal.

Stay safe and keep well!

Rigmor Baraas
Editor-in-chief

Fabrizio Zeri
Associate editor

Antonio Filipe Macedo
Associate editor

NORGES OPTIKER FORBUND

SOPTI Società Optometrica Italiana

Application, limits, scoring and improvements of Groffman Visual Tracing test

Alessio Facchin[1,2], Lavinia Giordano[1], Giovanni Brebbia[2] and Silvio Maffioletti[2,3]

[1]Materials Science Department & COMiB Research Centre in Optics and Optometry, University of Milano-Bicocca, Milano, Italy.
[2]Institute of Research and Studies in Optics and Optometry, Vinci, Italy.
[3]Degree course in Optics and Optometry, University of Torino, Torino, Italy.

Received April 14, 2020, accepted June 13, 2020.
Correspondence: alessiopietro.facchin@gmail.com

Abstract

The Groffman Visual Tracing (GVT) test is a psychometric oculomotor test comprising two cards with five contorted and intersected lines for the clinical evaluation of ocular movement. The participant starts from the one of letters at the top of the page, follows the line from the letter, and reports the corresponding number at the bottom of the page. The aim of this study is to evaluate two claims made by the original author of the test: "it is a developmental test", and "the feasibility of its application from primary school children up to adults". This was achieved by using the GVT test and a simplified version of it.

In two consecutive experiments, two groups of children and adults were tested. In the first experiment, 75 children (1st, 3rd, and 5th grade) and 25 adults underwent the GVT test. In the second experiment, 115 children from 1st to 5th grade underwent a simplified version of the GVT test. Total scoring, accuracy and execution time were evaluated.

In the first experiment, a developmental trend was found, but 24% of children in the 1st and 3rd grades did not follow any lines correctly due to the difficulty of the test. In the second experiment, all participants were able to perform the test, and the accuracy improved significantly with age ($p < 0.0001$), a sign of an evolutionary trend. The time required to follow the lines was found to decrease with age ($p < 0.0001$), and the accuracy of simplified version was better than the standard version ($p < 0.0001$).

A developmental trend was found, but the standard version of the GVT test has proven to be too difficult for younger children. The modified version provides best results. Children at or below the 5th grade should be tested using the modified version. Older children and adults can be tested with the standard version. Specific norms based on execution times and accuracy should be established.

Keywords: eye movements, Groffman test, visual tracing, saccade

Riassunto

Il Groffman Visual Tracing (GVT) è un test psicometrico oculomotorio costituito da due schede, sulle quali sono riprodotte cinque linee contorte che si intersecano e si sovrappongono più volte. I partecipanti iniziano da una lettera nella parte alta del foglio, seguono la linea e denominano il corrispondente numero, nella parte bassa del foglio. L'obiettivo di questo studio è di verificare due affermazioni dell'autore del test: "È un test per l'età dello sviluppo" e "Può essere adottato dall'inizio della scuola primaria fino all'età adulta". Tale valutazione è stata effettuata attraverso l'uso della versione standard e di una versione semplificata del test.

In due esperimenti sono stati testati due gruppi di bambini e di adulti. Nel primo esperimento, a 75 bambini (della 1°, 3° e 5° anno della scuola primaria) e 25 adulti è stato somministrato il GVT test. Nel secondo esperimento, a 115 bambini (dal 1° al 5° anno della scuola primaria) è stata somministrata una versione semplificata del test. Sono stati valutati il punteggio, l'accuratezza e il tempo di esecuzione.

Nel primo esperimento è stato trovato che la performance migliora con l'età, ma il 24% dei bambini del 1° e 3° anno non è riuscito a seguire correttamente alcuna linea, data la difficoltà del test. Nel secondo esperimento, tutti i partecipanti sono stati in grado di eseguire il test e l'accuratezza cresce significativamente con l'età ($p < 0.0001$), a conferma di un trend evolutivo. Il tempo di esecuzione ha evidenziato un decremento con l'età ($p < 0.0001$) e l'accuratezza della versione semplificata del test è risultata migliore rispetto alla versione standard ($p < 0.0001$).

Un miglioramento dei risultati in relazione all'età è stato trovato, ma la versione standard del GVT test si è rivelata troppo difficile per i bambini più piccoli. La versione modificata del GVT test si è invece rivelata più adeguata. Pertanto, con i bambini dal 1° al 5° anno della scuola primaria, è opportuno utilizzare la versione semplificata del test. Nei bambini più grandi e per gli adulti, la versione standard è risultata adeguata. Sarà necessario in seguito definire i valori normativi di riferimento riguardanti il tempo di esecuzione e l'accuratezza.

Parole chiave: movimenti oculari, Groffman test, visual tracing, saccadi

Introduction

In a policy statement defined by the American Academy of Optometry and the American Optometric Association (1997), it was stated that, in the visual testing of children with learning-related visual problems, a complete visual examination should be made (Scheiman & Rouse, 2006; Scheiman & Wick, 2019). In particular, visual pathway integrity, visual efficiency, and visual information processing need to be investigated. Specifically, the second area of visual efficiency included accommodation, binocular vision, and eye movements.

From a clinical point of view, for the evaluation of eye movements there are few standardized oculomotor tests available. Indeed, a precise and objective evaluation of ocular movement should be made objectively using an eye tracker (Scheiman & Wick, 2019, chapter 1). However, its cost and the length of time required for implementation, examination, and analysis restrict its primary use to research and it is not appropriate for use in clinical practice. Moreover, clear interpretation of the data is not easy because of the requirement for updated language-specific text and norms.

Consequently, other instruments, such as psychometric tests, were developed for the evaluation of eye movements (Richman & Garzia, 1987).

Several tests are available. The NSUCO is an observational structured scale test in which the examiner evaluates different aspects during the execution of a standard test of saccades and pursuit (Maples & Ficklin, 1990). The King-Devick is a visuo-verbal screening test to evaluate eye movements. It is based on the measurement of the speed of rapid number naming ((A. T. King, 1976)) and recently was applied as a concussion screening tool (Galetta et al., 2016; D. King et al., 2013). Similarly, the developmental eye movement test (DEM) is a visuo-verbal test to examine ocular movement in a reading like condition. It is widely used in developmental age groups and has norms for different languages (Baptista et al., 2011; Facchin et al., 2012;

Jimenez et al., 2003; Okumura & Wakamiya, 2010; Pang et al., 2010; Richman & Garzia, 1987; Serdjukova et al., 2016; Xie et al., 2016). In these "paper and pencil tests", the functioning of ocular movement is derived indirectly from the overall performance. Other than eye movements, several cognitive functions are involved in the overall performance of these tests: sustained attention, number recognition and retrieval, visual verbal integration time, speaking time, visuo-spatial attention, and other cognitive skills. For these reasons, these tests are not pure oculomotor tests (Ayton et al., 2009), but their ease of application and usefulness have been well demonstrated (Facchin et al., 2011; Maples & Ficklin, 1990; Moiroud et al., 2018; Richman, 2009; Richman & Garzia, 1987). Over the years, the DEM and King-Devick tests have been applied in a large number of investigations of their application and also to assess their psychometrical properties (Facchin et al., 2011; Facchin & Maffioletti, 2018; Moiroud et al., 2018; Rizzo et al., 2016; Tjarks et al., 2013).

The DEM test was largely used, but one of its limitations (also valid for the King-Devick) is the presence of verbal naming that takes from between 64% and 90% of the total horizontal time (Facchin et al., 2011). For this reason, there is a requirement for an oculomotor test without the naming component and the Groffman Visual Tracing (GVT) test acts in this manner (Groffman, 1966). The GVT test is an oculomotor "tracing" test in which a participant is required to follow a line in a group of five crowded lines from a letter at the top of the page to a number at the bottom. The number of times the line is followed correctly and the time spent to achieve this produce the final score (Groffman, 1966). Since the author reported that there are no naming skills required, this represents a simple performance test related to ocular movement.

In the first article by the author, visual tracing was correctly defined as "*the oculomotor skill used to follow a continuous stimulus from one point to another*" (Groffman, 1966) and it is related to both saccades and pursuits. The GVT test is not a real test of pursuits because of the lack of moving objects.

For the purposes of the author (Groffman, 1966), the GVT test complies with the following requirements and criteria: it provides a quantitative measure of oculomotor ability; it is a purely visual test (without other senses); there are no language factors; it is independent of cognitive factors; it is a developmental test; and it is applicable from children in kindergarten to adults.

Although mentioned in several textbooks (Chinn, 2014; Levi & Carney, 2009; Press, 2008; Press & Moore, 1993; Scheiman & Wick, 2019; Solan, 1982), the GVT test has received little attention in the literature. Only a few studies (Cui et al., 2017; Groffman, 1993; Langaas et al., 2002; Smaakjær et al., 2018) and some dissertations have cited this test and its application.

Specifically, GVT was used for the clinical assessment of eye movements in children with reading disabilities and with developmental coordination disorder (Langaas et al., 2002). The authors found that children with deficits perform poorly on the GVT test compared with controls, and a high number of children failed the GVT. In stroke patients, GVT was used for the assessment of oculomotor dysfunction before and after vision therapy. The results show an improvement of GVT score after vision therapy (Smaakjær et al., 2018).

As reported by Scheiman and Wick, 2019, in chapter 1, no studies indicating the psychometric properties and application of the GVT test have been published. Our main aims were to examine some of these properties. Specifically, we wanted to test the two last assertions of the author: "it is a developmental test" and "it is applicable from primary school to adults", together with performing a clinical evaluation of the test. We tested it in two consecutive experiments, as described below.

Experiment 1: standard version of the GVT test

The aim of the first experiment was to test the application of the GVT test in three groups of children and in one group of adults in order to evaluate the developmental trend and the feasibility of its application to participants ranging from primary school children to adults.

Methods

Participants

Children were recruited during a school screening program, and adult participants enrolled informally as volunteers. Only children with written informed consent from their relatives permitting them to take part in the study were enrolled. A total of one hundred and four participants were initially enrolled, but four (3 children and 1 adult) did not meet the inclusion criteria and were excluded. Finally, four groups of 25 participants were created, demographic characteristics are shown in Table 1. Adult participants were recruited randomly among patients attending an optometric office. Inclusion criteria were the presence of normal binocular vision assessed by cover test, the absence of ocular diseases reported by the participant or relatives, no history of refractive surgery, strabismus or amblyopia reported by children or relatives, and a visual acuity equal to or greater than +0.1 logMAR in each eye at near using a LEA symbols logMAR chart (Goodlite 250800, Elgin, IL, USA). All participants had no current or previous neurological or psychiatric disorders. Participants wore their own glasses or contact lenses (if needed) during testing. The study was carried out in accordance with the guidelines given in the Declaration of Helsinki and it was approved by the Board of Optics and Optometry of the University of Milano-Bicocca (January 14, 2019).

Table 1.: *Demographic characteristics for the four groups of participants in Experiment 1.*

Group	n	Mean age	SD	Range
1st class	25	6.5	0.5	6 – 7
3rd class	25	8.2	0.4	8 – 9
5th class	25	10.5	0.5	10 – 11
Adults	25	28.9	5.9	21 – 39
Total	100			

Groffman Visual Tracing Test

According to the original paper (Groffman, 1966), the Groffman Visual Tracing test was an oculomotor test based on two cards of 216 × 279 mm (i.e. US letter size). Each card comprised five separate continuous lines that intersected one another in a tangled pattern. The task was to "follow" each line as rapidly as possible without losing the line pattern. Each participant was asked to follow each line from a letter at the top of the page (A, B, C, D, and E) to a number (1 to 5) at the bottom. Execution times and final recognized numbers were recorded. Firstly, a demonstration card was placed on the lectern, and the instructions about the start, intersections, and ends were given. If the participant did not understand, the instructions for a demonstration card were repeated up to three times. After three repetitions, if the participant could not follow a single line on the demonstration card correctly, testing was terminated because of the failure to attain the minimum level of skill required for the execution of the test.

According to the original paper, the instruction was: "*This is a test to see how quickly and accurately you can follow a line using only your eyes. Look at the line that starts at the letter A. Follow it with your eyes. When it reaches another line (point to the first intersection),* *follow it through the gap (point to the broken line). This line goes under the whole line and continues through."* (Groffman, 1966). After the demonstration card, card A and B were administered in this order. The instruction for each card and line was: *"Now we are going to trace five more lines. Your score will depend on accuracy and speed so work quickly, but try not to make a mistake."* (Groffman, 1966).

The answer key was identical for cards A and B and was reported on a scoresheet. Scoring was performed using the original procedure, as reported in the test manual. Since the original score cannot differentiate between lower but accurate tracing (e.g. participant #4, 4 lines correctly followed slowly, 20 points) and fast but inaccurate tracing (e.g. participant #12, 2 lines correctly followed faster, 20 points), in order to have a better explanation of the results, we decided to take into account the accuracy (number of lines followed correctly that ranges from 0 to 5) and execution times separately, as many recent performance tests do. Consequently, in addition to the original scoring, the execution times of the lines correctly followed and the overall accuracy for each card were used for the analysis.

Procedure

For the children the GVT test was administered during a school screening program. The overall evaluation was performed in a quiet and well-illuminated room (approximately 400 lux). Firstly, children performed the basic screening program that included visual acuity at far and near, objective refraction, stereopsis, near point of convergence, objective observation, and cover test. After these tests, the child was seated at the desk wearing the proper refractive correction (if necessary), and the different cards were positioned on a lectern at 40 cm. A stopwatch was used to record the execution time. The card was positioned on a lectern and lines were covered by a blank sheet in order to avoid the child following lines before the start of the test. In this phase, only letters at the top of the page were visible. The examiner then spoke the letter, removed the blank sheet, and started the time. The examiner stopped the stopwatch when the participant gave the corresponding number. The number and the execution time were recorded on a scoresheet. If the number reported was incorrect, scoring was zero. If the number was correct, the execution time was recorded. If the participant lost the line, scoring was zero. The original score of the GVT test was computed using the table reported in the test manual. Adult participants were tested in an office under the same conditions as described above.

Statistical analysis and scoring

For comparative purposes, the data for the adults were analysed separately before they were included in the analysis of the children's data. Original scoring, accuracy, and execution times were analysed with a general linear model by using different structures of ANOVA to assess the evolutionary trend and to perform specific comparisons. Post-hoc analyses were performed with Tukey correction for multiple comparisons. Effect size was evaluated using partial eta squared. Since the execution times were available only for the lines followed correctly, we used these times for the analysis of the participants that have these data. Where appropriate, 95% confidence levels (CI) were reported. Statistical analyses and figures were performed with R statistical environment (R Core Team, 2019).

Results

The clinical application of the GVT test in 1st-grade children showed that execution of the task was very difficult for children at this age (6-7 years old), and the larger part refused to perform the second card B. For this reason, we decided to apply and consider only card A to the overall group of children. The second card "B" was administered only to adult participants. Consequently, the comparisons between groups were performed only for card "A" and cards "A" and "B" were compared only in adults.

Original Score

The original score was analysed using a one-way ANOVA with the between-participants factor Group with 4 levels (1st grade, 3rd grade, 5th grade, Adults). The results show that the factor Group was significant [$F(3,96) = 15.05, p < 0.0001, \eta_p^2 = 0.32$]. Post-hoc analyses showed significant differences between 1st and 5th grade ($p < 0.001$), between 1st grade and Adults ($p < 0.0001$), between 3rd and 5th grade ($p < 0.05$) and between 3rd grade and Adults ($p < 0.0001$). There was an improvement in performance with grade. The data are plotted in Figure 1.

On examining the raw data with respect to accuracy (see Table 2), we found that 24% of children in the 1st and 3rd grades could not correctly follow any lines and only 4% followed five lines correctly. In the 1st grade, 52% at best could follow only one line out of 5 on the first card "A" correctly.

Table 2.: *Accuracy of the GVT test according to group.*

Group	Lines	Frequency	Percent	Cumulative percent
1st grade	0	6	24.0	24.0
	1	7	28.0	52.0
	2	6	24.0	76.0
	3	3	12.0	88.0
	4	2	8.0	96.0
	5	1	4.0	100.0
	Total	25	100.0	
3rd grade	0	6	24.0	24.0
	1	3	12.0	36.0
	2	9	36.0	72.0
	3	5	20.0	92.0
	4	0	0.0	92.0
	5	2	8.0	100.0
	Total	25	100.0	
5th grade	0	0	0.0	0.0
	1	3	12.0	12.0
	2	3	12.0	24.0
	3	6	24.0	48.0
	4	8	32.0	80.0
	5	5	20.0	100.0
	Total	25	100.0	
Adults	0	0	0.0	0.0
	1	1	4.0	4.0
	2	5	20.0	24.0
	3	2	8.0	32.0
	4	6	24.0	56.0
	5	11	44.0	100.0
	Total	25	100.0	

Note. For each group, a frequency, percent, and cumulative percent was reported.

The accuracy between groups was analysed using a one-way ANOVA with the between-participants factor Group with 4 levels (1st grade, 3rd grade, 5th grade, Adults). The results show a significant effect of Group [$F(3,96) = 16.13, p < 0.0001, \eta_p^2 = 0.34$]. Post-hoc comparisons showed significant differences between 1st and 5th grade ($p = 0.0001$), between 1st grade and Adults ($p < 0.0001$), between 3rd and 5th grade ($p < 0.001$), and between 3rd grade and Adults ($p < 0.0001$). The mean accuracy improved with grade. The data are listed in Table 2 and plotted in Figure 2.

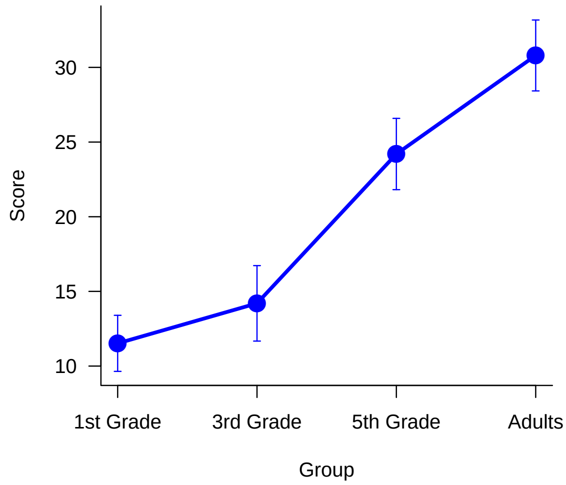

Figure 1.: *The score of GVT as a function of the group. Bars represent ±1 standard error of the mean (SEM).*

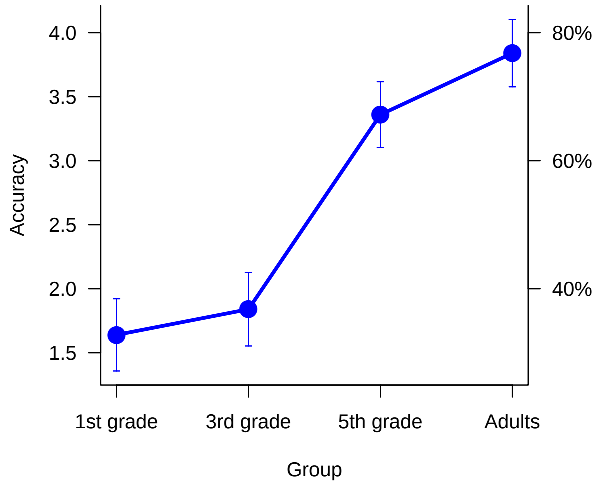

Figure 2.: *Evolution of accuracy during Grade for the GVT test. Bars represent ±1 SEM.*

The average score reported in the original paper (Groffman, 1966) was separated according to age. In order to compare our results with original norms for each child, we grouped all children participating according to their specific age. The comparisons for each age group with average score (t-test) showed a non-significant difference for all children and adults [in this last case the highest age available was used (12 and adults)]. However, large variability in our data explains these results. In fact, the comparison of variance (F-test) shows a significant difference ($p < 0.05$) for all ages except for 11-year old children.

Execution times

Execution times were analysed with a factorial ANOVA, with the factor Group with four levels (1st grade, 3rd grade, 5th grade, Adults), and the factor Line with 5 levels (A, B, C, D, and E). The results show a significant result for Group [$F(3, 247) = 6.01, p < 0.001, \eta_p^2 = 0.07$], a significant effect for Line [$F(4, 247) = 7.59, p < 0.0001, \eta_p^2 = 0.11$] and no significant interaction between Group and Line ($p = 0.97$). Post-hoc comparisons for the factor Group showed significant differences between 1st grade and Adults ($p < 0.001$) and between 5th grade and Adults ($p < 0.05$). The data separated by Group are plotted in Figure 3. Execution times improved with group, but this improvement was small, and there were significant differences in the execution time for each line.

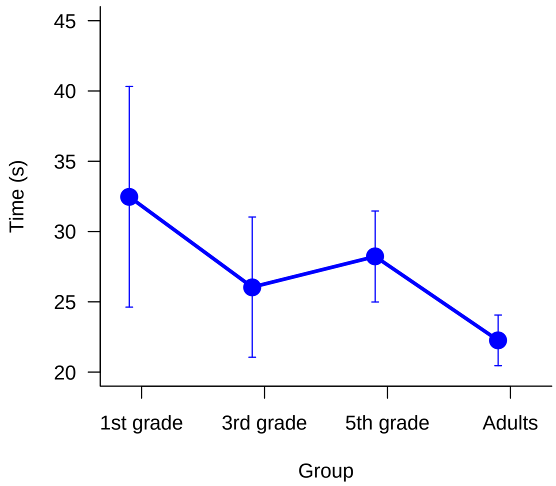

Figure 3.: *Execution times for the GVT test for card A as a function of Grade. Bars represent ±1 SEM.*

Correlations between original score, accuracy and execution times

Since all parameters that were evaluated (original score, accuracy, and times) improved significantly with grade, we tested their relationship. The results show a high positive correlation between original score and accuracy [$r = 0.938$ (0.909 – 0.958), $p < 0.0001$] and a medium negative correlation between original score and time [$r = -0.418$ (0.229 – 0.577), $p < 0.0001$]. The original GVT score was highly related to the accuracy, with a similar evolutionary trend as shown in Figures 1 and 3.

The GVT test in adults

Adult participants were able to perform both cards; their accuracy is reported in Table 3.

Table 3.: *Accuracy of the GVT test in Adults.*

Card	Lines	Frequency	Percent	Cumulative percentage
A	1	1	4.0	4.0
	2	5	20.0	24.0
	3	2	8.0	32.0
	4	6	24.0	56.0
	5	11	44.0	100.0
	Total	25	100.0	
B	1	1	4.0	4.0
	2	4	16.0	20.0
	3	4	16.0	36.0
	4	4	16.0	52.0
	5	12	48.0	100.0
	Total	25	100.0	

Note. For each card, a frequency, percent, and cumulative percent was reported.

The accuracy was analysed using a paired sample t-test. The result reveals no significant difference in accuracy between cards ($p = 0.87$).

For the execution times, data were analysed using a factorial ANOVA with the factor Card with two levels (A, B) and the factor Line with 5 levels (A – E). The results show a significant result for the factor Card ($F(1, 183) = 7.63, p < 0.01, \eta_p^2 = 0.04$), for the factor Line [$F(4, 183) = 4.50, p < 0.01, \eta_p^2 = 0.09$], and the interaction Card × Line [$F(4, 183) = 4.05, p < 0.01, \eta_p^2 = 0.08$]. Post-hoc comparisons for card A showed significant differences between line A and line C ($p < 0.001$), between line B and line C ($p < 0.05$), between line C and line D ($p < 0.05$) and between line C and line E ($p < 0.001$). For card B no significant differences were found. Each line on different cards had a different execution time. The results are plotted in Figure 4.

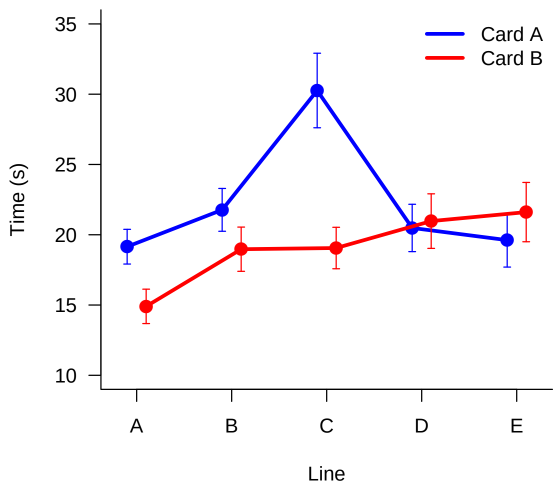

Figure 4.: *Execution times for Card A and B in adult participants. Bars represent ±1 SEM.*

Discussion

The aim of this first experiment was to test the developmental trend and the feasibility of the GVT test in ages ranging from primary school children to adults.

Compared to the original norms, the children tested generally performed in the mean values, but with large variability. Using the score reported in the original paper, it is not possible to differentiate between fast and inaccurate and slower and accurate participants. For these reasons, we decided to assess the accuracy and execution times separately. Without this division, the results below could not have been evaluated.

Observing accuracy and execution times, the GVT test shows an evolutionary trend, and we can confirm the statement made by the author that the GVT test is a developmental one.

Conversely, considering the second question, the task is too difficult for children in the 1st and 3rd grade. In order to allow this test to be applied at an optimum level in young children, we have performed a simplified version, as described below for the second experiment.

Experiment 2: simplified version of the GVT test

Based on the results of Experiment 1, with the aim of producing a better test for children, cards A and B were simplified by deleting lines B and D from both of them. Higher accuracy is expected compared to the original five lines and this raises the possibility of administering both cards even in younger children. The aim of this second experiment was to assess the performance of this modified version.

Material and methods

Participants

A different group of 115 children from 1st to 5th grade participated in the second experiment. They were equally subdivided into 23 participants for each grade. Inclusion and exclusion criteria were the same described earlier for Experiment 1.

Tests

Simplified GVT test

In order to simplify the GVT test, the original cards A and B were modified by deleting lines B and D from both of them. Consequently, the accuracy score was calculated over three lines for each card. For comparison between the original and simplified version, the accuracy was calculated in percent. Original and simplified version GVT cards are shown in Figure 5.

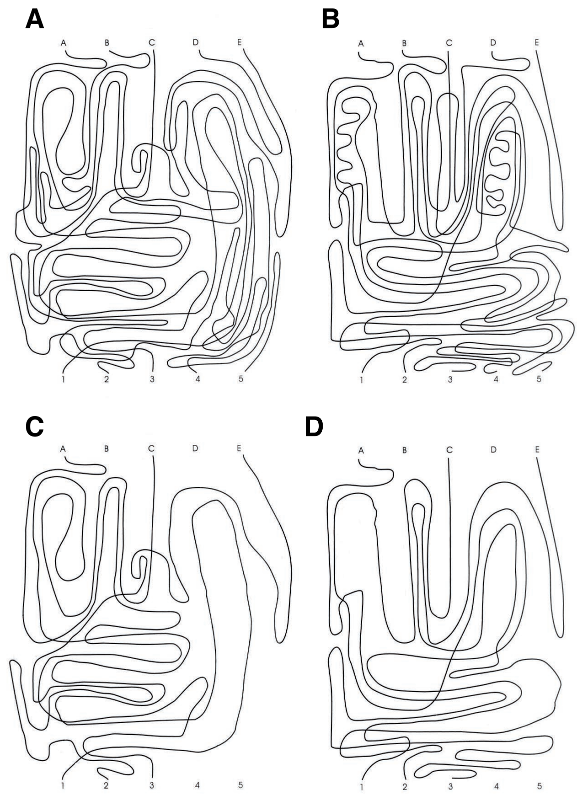

Figure 5.: *Original and simplified versions of the GVT test (demonstration card was not shown). Panels A and B show the original visual tracing test cards "A" and "B" respectively. Panels C and D show the simplified version of the GVT test cards "A" and "B".*

Procedure

The procedure was the same as that described earlier for Experiment 1.

Results

Accuracy

The accuracy for both cards is reported in Table 4.

In order to compare the accuracy of the simplified GVT test between grades, a repeated measure ANOVA was performed using the within factor Card with two levels (A and B) and the between factor Grade with five levels (1st – 5th). The results show a significant result only for the main factor Grade [$F(4, 110) = 9.6, p < 0.0001, \eta_p^2 = 0.26$]. Post-hoc pairwise comparisons for the factor Grade showed significant differences between 1st and 4th grade ($p < 0.0001$), between 1st and 5th grade ($p < 0.0001$), between 2nd and 5th grade ($p < 0.01$) and between 3rd and 5th grade ($p < 0.05$). Both cards present the same accuracy and developmental trend. The data are plotted in Figure 6.

Table 4.: *The frequency relative to the accuracy of the simplified version of the GVT test with three lines for cards A and B.*

		Card A			Card B		
Grade	Line	Frequency	Percent-age	Cumulative percentage	Frequency	Percent-age	Cumulative percentage
1	0	5	21.7	21.7	4	17.4	17.4
	1	7	30.4	52.2	9	39.1	56.5
	2	5	21.7	73.9	4	17.4	73.9
	3	6	26.1	100.0	6	26.1	100
	Total	23	100.0		23	100.0	
2	0	0	0.0	0.0	3	13.0	13.0
	1	6	26.1	26.1	7	30.4	43.5
	2	7	30.4	56.5	4	17.4	60.9
	3	10	43.5	100.0	9	39.1	100
	Total	23	100.0		23	100.0	
3	0	1	4.3	4.3	2	8.7	8.7
	1	6	26.1	30.4	5	21.7	30.4
	2	5	21.7	52.2	8	34.8	65.2
	3	11	47.8	100.0	8	34.8	100
	Total	23	100.0		23	100.0	
4	0	0	0.0	0.0	2	8.7	8.7
	1	3	13.0	13.0	1	4.3	13.0
	2	2	8.7	21.7	4	17.4	30.4
	3	18	78.3	100.0	16	69.6	100
	Total	23	100.0		23	100.0	
5	0	1	4.3	4.3	0	0.0	0.0
	1	1	4.3	8.7	2	8.7	8.7
	2	1	4.3	13.0	2	8.7	17.4
	3	20	87.0	100.0	19	82.6	100
	Total	23	100.0		23	100.0	

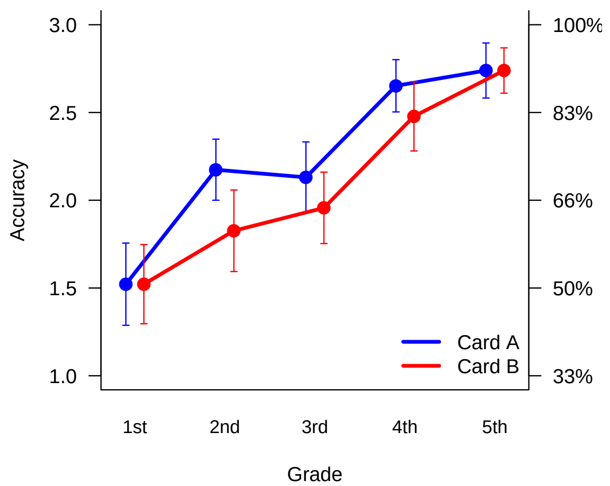

Figure 6.: *The accuracy between grades for the simplified version of the GVT test. Bars represent ±1 SEM.*

More importantly, the relative accuracy for the 1st, 3rd and 5th grade from the two versions of the GVT test (original and simplified) scored in percent were compared using a factorial ANOVA with the factor Experiment with two levels (Experiment 1 and Experiment 2) and Grade with three levels (1st, 3rd, 5th). The results show a significant difference for the main factor Experiment [$F(1,138) = 26.1, p < 0.0001, \eta_p^2 = 0.16$], for the main factor Grade [$F(2,138) = 19.8, p < 0.0001, \eta_p^2 = 0.22$], but no interaction between Experiment and Grade. The accuracy of the simplified version of the GVT test is significantly higher than for the original GVT test for children in 1st, 3rd and 5th grade. The results are plotted in Figure 7.

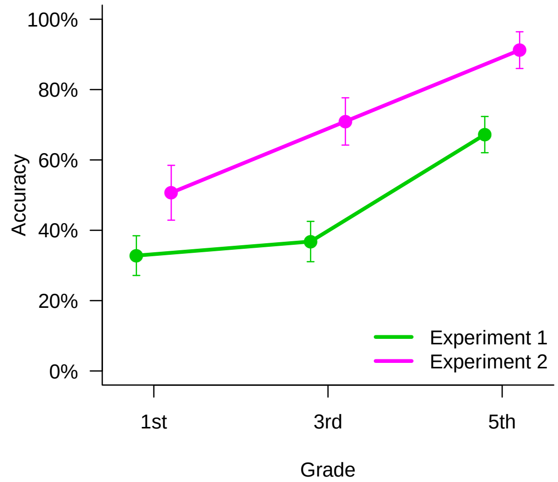

Figure 7.: *Comparison of accuracy between the standard (Experiment 1) and the simplified version (Experiment 2) of the GVT test. Bars represent ±1 SEM.*

Execution times

In order to evaluate the difference in execution times, a mixed ANOVA was performed with the between factor Grade with five levels (1st – 5th), the within factor Card with two levels (A and B) and the factor Line with three levels (A, C, E). A significant result was found for the main factor Grade [$F(4,465) = 14.61, p < 0.0001, \eta_p^2 = 0.11$], for the main factor Line [$F(2,465) = 11.15, p < 0.0001, \eta_p^2 = 0.05$] and the interaction Card ×Line [$F(2,465) = 7.05, p < 0.001, \eta_p^2 = 0.03$]. Post-hoc analyses for the factor Grade showed significant differences between 1st and 3rd grade ($p < 0.001$), between 1st and 4th grade ($p < 0.0001$), between 1st and 5th grade ($p < 0.0001$), between 2nd and 4th grade ($p < 0.0005$) and between 2nd and 5th grade ($p < 0.0001$). For Card A, post-hoc analyses showed significant differences between line A and line B ($p < 0.001$) and between line C and line E ($p < 0.0005$). For card B post-hoc analyses showed significant differences between line A and line C ($p < 0.05$) and between line A and line E ($p < 0.01$). Execution times decrease with Grade and are different between cards and lines. The results are plotted in Figure 8.

Discussion

The aim of the second experiment was to assess the performance of the simplified version of the GVT test compared to the original one.

With the simplification of the test, the overall accuracy increased significantly between grades. Qualitatively, using the original test, the majority of young children refused to perform the second card of test (B) due to its difficulty. With the simplified version, all the children were able to perform both cards. Even modified cards were performed in the same order (as is necessary for a clinical application), and both exhibited a similar accuracy. These results imply that the accuracy does not improve between cards, and consequently, there is not a learning effect, as occurs in other tests (Facchin & Maffioletti, 2018).

Conversely, each line on each card has a different and a specific execution time. Based on this result, a single scoring system cannot be applied to the execution time of all lines. Each line on each card requires specific scoring parameters.

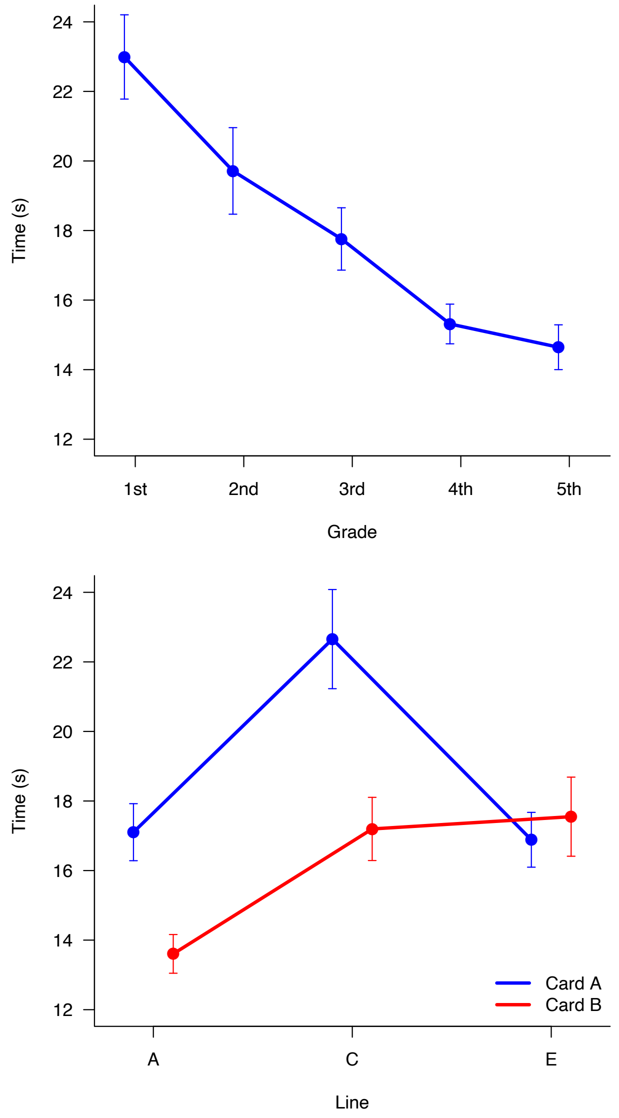

Figure 8.: *Execution times of the simplified test GVT. In the top graph, it was represented the mean execution times between Grades. In the bottom graph, the mean time of execution for each card and each line was reported. Bars represent ±1 SEM.*

We found that accuracy improves, and execution times decrease almost linearly according to grade in children. Consequently, the simplified GVT test is undoubtedly a developmental test.

General discussion

In this study we have aimed to apply the GVT test in a group of children and adults in order to test the two last assertions of the author of the test: "it is a developmental test", and "it is applicable from primary school to adults", together with a clinical evaluation of the test. We have found several interesting results.

With respect to the application of a standard test in young children, examining in detail the data with respect to accuracy in card A, we found a very poor result. A total of 24% were unable to follow a single line, 28% could correctly follow one line, and only 4% perform all lines correctly. Children in the 3rd grade performed in a similar manner, and only in the 5th grade were there discrete results (no one failed to follow all lines, and 20% followed all lines correctly). Young patients with reading disabilities (Langaas et al., 2002) and adult patients with stroke seem to have the same problems (Smaakjær et al., 2018).

Using the original score, no differentiation between styles of execution was possible. In some cases, accurate but slower children received a score equal or lower than faster but inaccurate children. The standard score was reported in the paper published in 1966, but there was no description of how this score was made. It was stated that 120 participants were tested, and the respective mean and standard deviation were reported. The original score was highly related to accuracy and moderately to time of execution.

Moreover, the time taken to execute the test was found to be different for each card and line. Consequently, a unique point – the scoring system seems not to be valid. For these reasons, we opted to analyse accuracy and execution times separately, as for the most part psychometric – performance tests do [e.g. in the domain of oculomotor test NSUCO (Maples & Ficklin, 1990) and DEM test (Richman & Garzia, 1987)].

Based on the overall results of the two experiments, we can review the criteria provided by the author, specifically, "*GVT is a developmental test*". We confirm that the ability improves during grades, as shown clinically by an increase of accuracy and in decreasing the time of execution during grades, in particular using the simplified version of the test.

"*GVT was applicable from primary school to adults*". This claim was partially correct. The GVT test was applicable in all ages but only in different forms or versions. In fact, the original version was too hard for the youngest children, and our modified and simplified version was found to be easier by children in primary school.

This study represents a baseline for future work that should take into account these observations. Future research on the GVT test could take into account its psychometric properties (validity, test-retest, and inter-examiner repeatability) and the development of specific norms, taking into account the overall accuracy (over 6 or 10 lines depending on age) and execution times separated for each card and line, preferably with modern scoring (i.e. percentile rank). The use of two separate scorings for execution times and accuracy permits clinicians to discriminate between different strategies that the participant may use.

When specific norms of GVT test are available, its first application will undoubtedly be in the field of oculomotor dysfunction, specifically in children with learning disabilities or other deficits. This test, together with other psychometric tests such as DEM and NSUCO could represent a valid and specific battery for oculomotor testing (Langaas et al., 2002).

In this study, we have reported that the GVT test demonstrates a clear evolutionary trend as an indication of validity, but the application of this test in adults could also be useful. It represents an oculomotor – performance test, and with the specific norms, it could be a valuable test in the evaluation of patients with special needs (Taub et al., 2012), in particular those with specific oculomotor problems such as patients with brain-injury (Gallaway et al., 2017; Scheiman et al., 2017; Smaakjær et al., 2018) and adults with learning disability.

Acknowledgements

We would like to thank Silvia Tavazzi for helpful comments on an early version of the manuscript.

References

Ayton, L. N., Abel, L. A., Fricke, T. R., & McBrien, N. A. (2009). Developmental eye movement test: what is it really measuring? *Optometry and Vision Science*, *86*, 722–730. https://doi.org/10.1097/OPX.0b013e3182195dae

Baptista, A. M., de Sousa, R. A., de Morais Guerra Casal, C. C., Marques, R. J., & da Silva, C. M. (2011). Norms for the developmental eye movement test for Portuguese children. *Optometry and Vision Science*, *88*, 864–871. https://doi.org/10.1097/OPX.0b013e3182195dae

Chinn, S. (2014). *The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties*. Taylor & Francis.

Cui, J., Zhang, Y., Cheng, D., Li, D., & Zhou, X. (2017). Visual Form Perception Can Be a Cognitive Correlate of Lower Level Math Categories for Teenagers. https://doi.org/10.3389/fpsyg.2017.01336

Facchin, A., Maffioletti, S., & Carnevali, T. (2011). Validity reassessment of developmental eye movement (DEM) test in the Italian population. *Optometry and Vision Development*, *42*, 155–167. https://doi.org/10.3389/fpsyg.2018.01279

Facchin, A., & Maffioletti, S. (2018). The reliability of the DEM test in the clinical environment. *Frontiers in Psychology*, *9*.

Facchin, A., Maffioletti, S., & Carnevali, T. (2012). The developmental eye movement (DEM) test: normative data for Italian population. *Optometry and Vision Development*, *43*.

Galetta, K. M., Liu, M., Leong, D. F., Ventura, R. E., Galetta, S. L., & Balcer, L. J. (2016). The King-Devick test of rapid number naming for concussion detection: meta-analysis and systematic review of the literature. *Concussion*, *1*(2). https://doi.org/10.2217/cnc.15.8

Gallaway, M., Scheiman, M., & Mitchell, G. L. (2017). Vision therapy for post-concussion vision disorders. *Optometry and Vision Science*, *94*(1), 68–73. https://doi.org/10.1097/OPX.0000000000000935

Groffman, S. (1966). Visual tracing. *Journal of American Optometric Association*, *37*, 139–141.

Groffman, S. (1993). Correlation between cognitive processing and ocular motility. *Optometry and Vision Science*, *70*(5), 380–383.

Jimenez, R., Gonzalez, M. D., Perez, M. A., & Garcia, J. A. (2003). Evolution of accommodative function and development of ocular movements in children. *Ophthalmic and Physiological Optics*, *23*, 97–107. https://doi.org/10.1046/j.1475-1313.2003.00093.x

King, A. T. (1976). *The proposed King-Devick Test and its relation to the Pierce Saccade and reading level*. Available from the Carl Shepherd Memorial Library.

King, D., Brughelli, M., Hume, P., & Gissane, C. (2013). Concussions in amateur rugby union identified with the use of a rapid visual screening tool. *Journal of the Neurological Sciences*, *326*(1-2), 59–63. https://doi.org/10.1016/j.jns.2013.01.012

Langaas, T., Aadne, R., Dahle, E. C., Hansen, A. M. H., Horgen, G., Myhren, D. J. T., Myklebust, A., Rønnestad, T., Storengen, T., & Wiik, M. S. (2002). Clinical assessment of eye movements in children with reading disabilities and with Developmental Coordination Disorder (DCD). *Investigative Ophthalmology & Visual Science*, *43*(13), 4661.

Levi, D. M., & Carney, T. (2009). Crowding in Peripheral Vision: Why Bigger Is Better. *Current Biology*, *19*(23), 1988–1993. https://doi.org/10.1016/J.CUB.2009.09.056

Maples, W. C., & Ficklin, T. (1990). Comparison of eye movement skills between above average and below average readers. *Journal of Behavioural Optometry*, *1*(4), 87–91.

Moiroud, L., Gerard, C. L., Peyre, H., & Bucci, M. P. (2018). Developmental Eye Movement test and dyslexic children: A pilot study with eye movement recordings. *PloS One*, *13*(9), e0200907. https://doi.org/10.1371/journal.pone.0200907

Okumura, T., & Wakamiya, E. (2010). *Visual Skills in Children with Learning Difficulties*. Meijitosho Shuppan Corporation.

Pang, P. C., Lam, C. S., & Woo, G. C. (2010). The Developmental Eye Movement (DEM) test and Cantonese-speaking children in Hong Kong SAR, China. *Clinical and Experimental Optometry*, *93*, 213–223. https://doi.org/10.1111/j.1444-0938.2010.00470.x

Press, L. J. (2008). *Applied Concepts in Vision Therapy*. Optometric Extension Program Foundation.

Press, L. J., & Moore, B. D. (1993). *Clinical Pediatric Optometry*. Butterworth-Heinemann. https://books.google.it/books?id=YNpsAAAAMAAJ

Richman, J. E. (2009). *Developmental Eye Movement Test, Examiner's Manual, version 2.0*. Bernell Corp.

Richman, J. E., & Garzia, R. P. (1987). *Developmental Eye Movement Test, Examiners Booklet, version 1*. Bernell Corp.

Rizzo, J.-R., Hudson, T. E., Dai, W., Birkemeier, J., Pasculli, R. M., Selesnick, I., Balcer, L. J., Galetta, S. L., & Rucker, J. C. (2016). Rapid number naming in chronic concussion: eye movements in the King–Devick test. *Annals of Clinical and Translational Neurology*, *3*(10), 801–811. https://doi.org/10.1002/acn3.345

Scheiman, M., & Rouse, M. W. (2006). *Optometric management of learning-related vision problems*. Elsevier Health Sciences.

Scheiman, M., Talasan, H., Mitchell, G. L., & Alvarez, T. L. (2017). Objective assessment of vergence after treatment of concussion-related CI: a pilot study. *Optometry and Vision Science*, *94*(1), 74. https://doi.org/10.1097/OPX.0000000000000936

Scheiman, M., & Wick, B. (2019). *Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders* (5th). Lippincott Williams & Wilkins.

Serdjukova, J., Ekimane, L., Valeinis, J., Skilters, J., & Krumina, G. (2016). How strong and weak readers perform on the Developmental Eye Movement test (DEM): norms for Latvian school-aged children. *Reading and Writing*, 1–20. https://doi.org/10.1007/s11145-016-9671-7

Smaakjær, P., Tødten, S. T., & Rasmussen, R. S. (2018). Therapist-assisted vision therapy improves outcome for stroke patients with homonymous hemianopia alone or combined with oculomotor dysfunction. *Neurological Research*, *40*(9), 752–757. https://doi.org/10.1080/01616412.2018.1475321

Solan, H. A. (1982). *The treatment and management of children with learning disabilities*. Charles C Thomas Pub Ltd.

Taub, M. B., Bartuccio, M., & Maino, D. (2012). *Visual Diagnosis and Care of the Patient with Special Needs*. Wolters Kluwer Health.

Tjarks, B. J., Dorman, J. C., Valentine, V. D., Munce, T. A., Thompson, P. A., Kindt, S. L., & Bergeron, M. F. (2013). Comparison and utility of King-Devick and ImPACT® composite scores in adolescent concussion patients. *Journal of the Neurological Sciences*, *334*(1-2), 148–153. https://doi.org/10.1016/j.jns.2013.08.015

Xie, Y., Shi, C., Tong, M., Zhang, M., Li, T., Xu, Y., Guo, X., Hong, Q., & Chi, X. (2016). Developmental Eye Movement (DEM) test norms for Mandarin Chinese-speaking Chinese children. *PloS One*, *11*, e0148481. https://doi.org/10.1371/journal.pone.0148481

Optometry Students' and Educators' Perceptions of Group Work and Peer Assessment in Italian Higher Education

Fabrizio Zeri[1,2,3], Riccardo Cervio[4], Marta Mosci[4], Silvia Tavazzi[1,2] and Shehzad A. Naroo[3]

[1]University of Milano Bicocca, Department of Materials Science, Milan, Italy.
[2]University of Milano Bicocca, Research Centre in Optics and Optometry (COMiB), Milan, Italy.
[3]Ophthalmic Research Group. School of Life and Health Sciences, Aston University, Birmingham, UK.
[4]University of Milano Bicocca, Optics and Optometry degree course, Milan, Italy.

Received December 19, 2019, accepted June 26, 2020.
Correspondence: fabrizio.zeri@unimib.it

Abstract

In health-related professions, education has unique challenges. Problem-based learning can be extremely useful and driven by strategies such as group-work (GW) and peer assessment (PA), which are both used as formative and assessment tools. This study aimed to explore experience and perceptions about GW and PA held by educators and students in optometry. In a first survey, 45 Italian educators (43.8 ± 13.0 years old) of optometric clinical modules answered an email questionnaire investigating their attitudes towards GW and PA. In a second survey, 66 3rd-year undergraduates (22.5 ± 2.0 years old) answered a questionnaire investigating the perception and attitudes towards GW and PA at the beginning and at the end of a module of Advanced Optometry structured with a formative/summative GW activity with a final PA. Two-thirds of optometry educators declared they use GW, but not as a summative assessment tool. Only a quarter of the sample answered that they used PA at least once. Educators' attitudes towards GW were more positive than PA ($p < 0.001$). About 60% and 80% of the interviewed students stated they have never participated in GW and PA, respectively. Students' pre-course attitudes towards GW and PA resulted in values close to the middle of the scale with no significant differences and positive correlations between them ($p < 0.001$). When students' GW attitudes were compared with educators' GW attitudes, the latter were more positive. Students' post-course attitudes towards GW and PA were enhanced. Although GW and PA are considered very good strategies to improve teaching, the results of the present study have demonstrated that the use of these strategies in Italian optometric higher education is limited. However, the study has also demonstrated that Italian optometry educators have positive attitudes towards "social" teaching strategies especially for GW. Furthermore, optometry students showed improved attitudes towards these strategies once exposed to them. Overall, the results of the study open the possibility to integrate "social" teaching strategies to improve the effectiveness of optometry education.

Keywords: Group-work, peer assessment, optometry education, problem-based learning.

Riassunto

La formazione accademica delle professioni sanitarie presenta delle criticità uniche. L'apprendimento basato su problemi (problem-based learning) può essere estremamente utile e condotto usando il lavoro di gruppo (group-work; GW) e la valutazione fra pari (peer assessment; PA) sia come strumenti di formazione che di valutazione finale degli studenti. Questo studio ha puntato ad esplorare l'esperienza e la percezione verso il GW e il PA da parte di educatori e studenti in optometria. In un primo sondaggio 45 docenti italiani di moduli di optometria clinica (43.8 ± 13.0 anni) hanno risposto ad un questionario inviato per mail che ha indagato le loro attitudini verso il GW e il PA. In un secondo sondaggio 66 studenti del terzo anno della laurea triennale in optometria hanno risposto ad un questionario che ha indagato le loro attitudini verso il GW e il PA prima e dopo la frequenza del modulo di Optometria Avanzata strutturato con un'attività formativa e valutativa di GW e con un PA finale. Due terzi dei docenti in optometria hanno dichiarata di usare il GW, ma non come strumento di valutazione finale degli studenti. Solo un quarto del campione ha risposto di aver usato il PA almeno una volta. L'attitudine dei docenti verso il GW è risultata più positiva che verso il PA ($p < 0.001$). Tra gli studenti intervistati rispettivamente il 60% e l'80% hanno dichiarato di non avere mai partecipato al GW e al PA. L'attitudine pre-corso degli studenti verso il GW e il PA è risultata su valori medi con assenza di differenze significative e correlazione positiva tra loro ($p < 0.001$). Quando le attitudini degli studenti verso il GW sono state comparate con quelle dei docenti, in questi ultimi sono risultate più positive. Comunque, l'attitudine post-corso degli studenti verso il GW e il PA è cresciuta. Nonostante il fatto che il GW e il PA sono considerate strategie molto valide per migliorare la didattica, i risultati del presente studio hanno dimostrato che il loro uso nell'educazione universitaria in optometria è limitato. Comunque, lo studio ha anche dimostrato che i docenti di optometria italiani hanno attitudini positive verso l'insegnamento che usa forme d'interazione "sociale", soprattutto per il GW. Inoltre, gli studenti di optometria hanno mostrato che l'attitudine verso queste strategie migliora una volta esposti a queste metodiche. Nel complesso, i risultati di questo studio aprono alla possibilità d'integrare l'insegnamento che usa l'interazione "sociale" per migliorare l'efficacia della formazione optometrica.

Parole chiave: lavoro di gruppo, valutazione tra pari. formazione in Optometria, apprendimento basato su problemi.

Introduction

Learning is a social activity. Race (2007) noted that 'learning from others is the most instinctive and natural of all the learning contexts experienced'. In health-related professions, such as medicine, nursing, and optometry, education is particularly challenging since the students have to recall a broad theoretical knowledge and skills in a clinical setting (Frenk et al., 2010). Moreover, the ability to think critically and work effectively in a team is required (Hrynchak & Spafford, 2015). There are many ways to improve teaching in Higher Education (HE), especially for health-related professions, using the positive influence of social activity. Two of these ways are group-work (GW) and peer-assessment (PA).

GW is where a small group of students meets to discuss a particular issue or perform a particular task. Student-student interaction is at the base of GW functioning, leading to an enhanced experience of learning (Biggs & Tang, 2011; Fry et al., 2008). There are two slightly different forms of learning in a group: collaborative and cooperative (Bruffee, 1995; Hammar Chiriac, 2014; Panitz, 1999). Collaborative learning includes interaction, collaboration and utilization of the group's competencies; whereas cooperative learning happens without direct interaction, for example students independently producing a different part of the group's project work would be cooperative

(Bennett & Dunne, 1992; Galton & Williamson, 1992). Whilst cooperative learning is teacher-centred, collaborative learning is more student-centred (Panitz, 1999) and more appropriate for learning that requires a critical approach (Bruffee, 1995). GW is becoming increasingly common in HE (Hammar Chiriac, 2014) especially as a formative tool and it is now largely utilized in schools and universities worldwide (D. W. Johnson & Johnson, 2009). Also, in optometry programs there is more attention to the use of student-centred learning models (Hrynchak & Spafford, 2015; Weisinger & Prideaux 3, 2011). However, the use of strategies of GW as a formative assessment tool is a more recent phenomenon but could be useful in reducing teachers' marking workloads and in promoting students' interpersonal skills (Biggs & Tang, 2011). The assessment of GW usually focuses on social skills and the group processes but can also be extended to include knowledge acquisition (Forsell et al., 2020). There is robust evidence supporting the effectiveness of GW in learning (D. W. Johnson et al., 2014). In particular, a series of specific outcomes will be triggered by positive interdependence within a work group rather than simply motivating individuals to work harder. The elaboration of known content, deriving standards for judging better, reflective awareness of how one arrives at a given position, applying theory to practice, the development of new insights and the more frequent use of higher level reasoning strategies are common positive outcomes (Biggs & Tang, 2011). Ortiz et al. (1996) demonstrated that teamwork resulted in better individual performance. However, this happened after participants became more skilled in the teamwork element, about five weeks after the beginning of the study. Moreover, group membership alone is not sufficient to produce better achievements since positive interdependence is also required (Hwong et al., 1993). In science education, working in small groups was effective in improving significantly higher final exam grades with respect to individual study, especially among the least prepared students (Gaudet et al., 2010). All these benefits could be particularly important in optometry education. In terms of subjective perception, the experience of students with GW and group assessment is extremely positive. Hammar Chiriac (2014) found out that the majority of students experienced that working in groups facilitated learning of academic knowledge, collaborative abilities or both. Students feel that GW is a method that leads to the development of a wider breadth of knowledge through discussion, clarification of ideas and evaluation of the ideas of others (Hassanien, 2006). Students perceive that the work group provides a secure support system which cannot be obtained when working individually (Janssen et al., 2010; Pfaff & Huddleston, 2003). Student attitudes toward small-group learning improved after the experience of GW (Gaudet et al., 2010; Walker, 2001). Finally, it has been shown that GW could be more suitable for some categories of students (e.g. women and minority groups) than teaching methods based on individual learning ability (Boud et al., 1999).

PA is another teaching and learning strategy that uses the positive influence of social activity. Here students make assessment decisions on another student's work or on group work (Forsell et al., 2020). It can be used for almost any aspect of student performance and can be either formative or summative (Race, 2001). There are a series of advantages of PA such as improving autonomy, responsibility and self-efficacy, finding out more about assessment culture, learning from each other's successes and weaknesses, and enhancing problem-solving skills (Falchikov, 2007; Race et al., 2005; Thomas et al., 2011). PA can also save the teacher time; however, it has been demonstrated that students tend to give lower grades to the better performing students than their teacher did (Sadler & Good, 2006). PA effectiveness can be improved if the educator explains clearly to the students how they will benefit from participating (Biggs & Tang, 2011; Carless et al., 2006; Falchikov & Goldfinch, 2000; Thomas et al., 2011). However, PA has some drawbacks because it can be unreliable and can challenge the traditional power relationship between learner and teacher (Leach et al., 2001).

In biomedical education two approaches use GW and PA: the problem-based learning (PBL) (Barrows & Pickell, 1991) and the team-based learning (TBL) (Hrynchak & Spafford, 2015). They were both successfully used in optometry education (Hrynchak & Spafford, 2015; Lovie-Kitchin, 1991).

Although the cooperative learning theory and knowledge is well established among Italian researchers in education (Benati & Chiari, 2008; Comoglio, 1999), experience of GW, PBL or TBL based programs in biomedical education in Italy is not so common (Lotti, 2015). The present study aimed to explore the experience and perceptions of GW and PA held by educators and students in the field of Optometry in Italy. This field is particularly interesting because optometry is a health-related teaching discipline that only reached HE level in Italy at the beginning of this century, so no effects of previous structured traditions exist and no data is available so far.

Methods

Study 1: Optometric Educators Survey

Educators of optometric clinical modules (contact lenses, refraction, ophthalmic dispensing, binocular vision, visual optics and low vision) who were currently engaged in teaching of optometry courses at six Italian Universities and two private schools were invited, on a voluntary basis, to complete an anonymous email questionnaire. The study was conducted following the tenets of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study. Data was collected over a 3-month period from the end of 2017 to the beginning of 2018.

Questionnaire

The questionnaire (see Figure A.1) used in the interviews was developed to investigate the educators' experience and perceptions of GW and PA. The questionnaire covered three main sections: (1) Educator's information; (2) Educator's experience and perceptions about GW; and (3), Educator's experience and perceptions about PA. The educator's perceptions towards GW and PA (section 2 and 3) were assessed each through four questions adapted from the questionnaire used by Walker (2001). The list of advantages and disadvantages of GW and PA (section 2 and 3) was created by the authors through a process of consensus with a focus group.

Study 2: Optometric Students Survey

This second study was carried out during the first semester module of Advanced Optometry run in the 3rd year of the BSc in Optics and Optometry at the University of Milano Bicocca in Milan in the academic year 2017/2018. The aim of the study was to explore the perceptions of GW and PA held by students and then evaluate any possible change in their perceptions after they attended the module in which GW and PA were experienced. More specifically, 3rd-year students attending the module of Advanced Optometry were required to participate in a formal collaborative GW activity during the semester. This activity required them to be assigned randomly to small groups of maximum seven students to produce, for the end of semester, a 15-minute oral presentation about how to cope with a specific clinical dilemma. Each group was given a different dilemma on a certain subject related to clinical optometry highlighting the importance of a brainstorming modality of discussion (Biggs & Tang, 2011), in the light of evidence-based literature. Although the core of GW was student–student interaction, a preliminary phase was needed in which the module leader introduced the

GW in terms of the task, rules that should be used by the group, positive interdependence and individual accountability, expected social skills to be used, organizational tips (such as the appointment of group leader, modality of meeting etc.) activities timetable, and criteria for success. Two follow-up meetings were set up during the semester. Considering the importance of an evidence-based approach required in the task, a lecture on this subject was provided before the GW started. Moreover, to try to deliver the importance of positive interdependence and individual accountability during the GW, an interactive group game was conducted to demonstrate the dynamics of GW. The assessment of each group presentation was done during a unique presentation day at the end of the semester. Marks were determined by a co-assessment as the average of PA and staff assessment (conducted by the module leader and tutors) attributed independently. Co-assessment was preferred to pure PA because it allowed the tutors and module leader to keep a certain control over the assessment marks (Dochy et al., 1999; Freeman, 1995). Assessment was performed using a marking scheme on the four following criteria: appropriate description of the relevant aspects of the dilemma; strength of literature reviewed; coherence; and strength of the proposed clinical management of the dilemma and communication performance. The assessment formed 15% of the course overall assessment and the GW was rated as a team, so each individual group member received the same mark (White et al., 2007) although the fairness related to awarding all group members with the same mark has been criticized in a study carried out in optometry education (Conway et al., 1993).

GW and PA activity were tailored to align constructively the tasks to a specific learning outcome of the module that looked at the ability of the students to use evidence-based approach in order to make clinical decision and solve a problem in specific contexts of optometry. Considering that GW and PA were introduced for the first time in this module, this survey to study changes in attitudes and perception was particularly important in helping to decide on the continued use of GW and PA. The survey was carried out through a pre-course questionnaire that was handed out at the beginning of the first lecture of the course, and a post-course questionnaire that was handed-out at the end of summative PA of GW presentations at the end of the semester. The study was conducted following the tenets of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study.

Questionnaires

The pre-course questionnaire and the post-course questionnaire were identical except that in the former the questions about attitudes versus GW and PA (Q1–Q8) were phrased in the present tense, whilst in the second the past tense was used. In Figure A.2 only the pre-course questionnaire is reported. The pre- and post-questionnaire were paired together using the personal course number. The questionnaire covered three main sections: (1) Student's information; (2) Student's experience and perceptions about GW; and (3), Student's experience and perceptions about PA. The student's perceptions towards GW and PA (section 2 and 3) were assessed through four questions adapted from the questionnaire used by Walker (2001). The list of advantages and disadvantages of GW and PA (section 2 and 3) was the same as used above for educators (Figure A.1). However, for advantages three additional options about specific skills developed in the module, were included.

Statistical Analysis

Data about experience and perceptions with GW and PA are presented descriptively for both educators and students. Non-parametric statistics were used to analyze the data. To explore if the GW and PA experience was biased by personal demographics of the interviewees a chi-squared (χ^2) and Kruskal Wallis ANOVA were used. According to Walker (2001), to explore the relationship between perceptions of GW and PA, the ratings for the four questions (Q1–Q4) about GW and the four questions (Q5–Q8) about PA were added together (hereafter referred to as overall perception rating) for educators or students. The Spearman correlations (r_s) and paired comparison (Wilcoxon-signed rank test) between overall perception rating of GW and PA were calculated for educators and students, respectively. For the student group only, the GW and PA perceptions in the two conditions (pre vs. post) were compared by a Wilcoxon-signed rank test. Also, the comparison between the main important GW and PA advantages and disadvantages perceived by students pre- and post-course were compared using a chi-squared (χ^2) test. Finally, educators' and students' perceptions of GW (Q1–Q4) and PA (Q5–Q8) were compared with a Mann-Whitney Test.

Results

Study 1: Optometry Educators Survey

Forty-five Italian educators (mean ± standard deviation age of 43.8 ± 13.0 years, range 24–67 years; 11 females and 34 males) from five Universities (Florence, Milan, Padua, Rome, and Turin) and two private optometry schools (Bologna and Vinci) answered the questionnaire.

Twenty-three (51.1%), six (13.3%) and 16 (35.6%) of interviewees stated they have used GW "more than once", "once" and "never" respectively. Amongst the interviewees who declared use of GW none used this activity as a summative assessment tool. Six (13.3%), five (11.1%) and 34 (75.6%) of the educators interviewed stated they have used PA, "more than once", "once" and "never". Among interviewees who declared that they use PA, only one out of eleven used this activity as a summative assessment tool. The effect of personal variables on experience with GW and PA are reported in Table 1.

Non-parametric ANOVA showed that differences in experience with GW is linked with differences in years of experience, with more experienced educators having used GW more. Although non-parametric ANOVA did not show a significant effect of the 3 levels of GW experience of educators with their age, paired comparisons showed that educators who declared that they had used GW more than once are older than those who declared having never used GW (Mann-Whitney, $p < 0.01$). Non-parametric ANOVA also showed that differences in experience with PA is not linked with differences in years of teaching experience. However, paired comparisons between educators who declared that they had used PA more than once, and those who declared never having used PA, showed a significant difference both for age and years of teaching (Mann-Whitney, $p = 0.01$ and $p = 0.03$, respectively).

The educators' perceptions of GW and PA are reported in Figure 1. No significant correlation between the overall perception rating for GW (Q1–Q4) and PA (Q5–Q8) was found ($r_s = 0.23, p = 0.13$). Moreover, Wilcoxon-signed-rank test showed that there is a significant difference between the overall perception rating for GW and PA ($p < 0.001$).

The main important advantages and disadvantages of GW and PA perceived by educators are reported in Table 2.

Table 1.: *Educators' experience with 'group work' and 'peer assessment' as a function of personal variables of interviewees (N = 45).*

Experience	Gender (*N*: males/females)	Age (years) (median, mean ±*SD*)	Teaching experience (years) (median, mean ±*SD*)	Institute/s of teaching (*N*: academia/school/both)	Module taught (*N*: one/more than one)
			Group-work		
Never	11/5	39.0; 39.3 ±10.4	3.5; 8.0 ±8.7	13/1/2	13/3
Once	18/5	39.0; 39.0 ±12.5	5.5; 10.3 ±10.2	1/3/2	5/1
More than once	5/1	46.0; 48.1 ±13.4	22; 20.4 ±13.9	4/10/9	11/12
Comparison	$\chi^2 = 0.69$, $p = 0.7$	Kruskal Wallis, $p = 0.07$	Kruskal Wallis, $\mathbf{p = 0.01}$	$\chi^2 = 17.9$, $p = 0.01$	$\chi^2 = 5.7$, $p = 0.06$
			Peer assessment		
Never	25/9	40; 41.6 ±12.4	7.5; 12.8 ±12.6	17/12/5	25/9
Once	6/0	46; 45.6 ±17.0	10; 17.2 ±17.5	0/1/4	2/4
More than once	3/2	54.5; 54.3 ±5.6	28; 23.0 ±9.8	1/1/4	2/3
Comparison	$\chi^2 = 2.67$, $p = 0.26$	Kruskal Wallis, $p = 0.07$	Kruskal Wallis, $p = 0.12$	$\chi^2 = 14.3$, $\mathbf{p < 0.001}$	$\chi^2 = 5.1$, $p = 0.08$

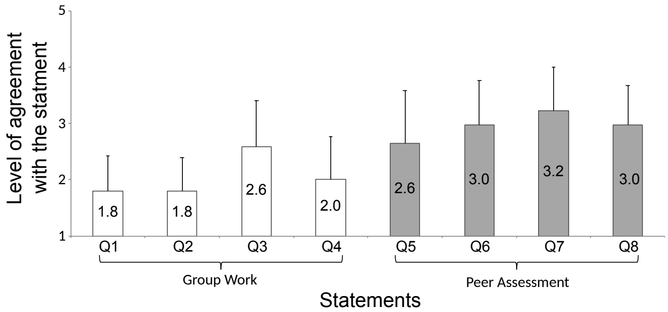

Figure 1.: *Mean and SD of the results of the four questions about GW (white bars) and PA (grey bars) asked to Educators (N = 45).*

Table 2.: *Main advantages and disadvantages of 'group work' and 'peer assessment' perceived by educators (N = 45).*

Main advantage	N	%	Main disadvantage	N	%
			Group-work		
Improving communication skills, discussion and debate	25	55.6	Participants' contributions are different	27	60.0
Improving subject knowledge	6	13.3	Strong personality of some participants can negatively affect collaboration of peers	6	13.3
Improving collaboration among peers	6	13.3	Final assessment of GW is more difficult	6	13.3
Improving problem solving skills	6	13.3	Personality difference can create anxiety and stress	3	6.7
Improving planning skills	1	2.2	Other	2	2.2
Not answered	1	2.2	Not answered	1	2.2
			Peer assessment		
Developing critical reflection	27	60.0	Students are not inclined to judge peers	16	35.6
Encourage commitment	7	15.6	Students are less accurate and expert than lecturers	15	33.3
Students can learn from success/failures of peers	5	11.1	Students have the bias to judge all peers in the same way	10	22.2
Learning improve if students are involved in assessment criteria	4	8.9	Students can give poor ranks for personal reasons	2	4.4
Other	1	2.2	Other	2	4.4
Not answered	1	2.2			

Study 2: Optometry students Survey

Seventy 3rd-year undergraduates answered the first questionnaire but only 66 (mean ± standard deviation of age = 22.5 ± 2.0 years; range: 20-29) were included in the analysis because they also answered the second questionnaire. Three (4.5%), 20 (30.3%) and 41 (62.1%) students interviewed stated that they have participated in GW "more than once", "once" and "never", respectively. Two students did not respond to the question relating to previous experience with GW. Six (9.1%) and 50 (81.8%) students interviewed stated they had participated in GW "once" and "never", respectively. Six students did not respond to the question relating to previous experience with PA. Experience with GW and PA was not affected by personal demographics of interviewees, such as gender, age or average marks obtained in their university career (Table 3).

Table 3.: *Students' experience with 'group work' and 'peer assessment' as a function of personal variables of interviewees.*

Experience	Gender (N: males/females)	Age (years) (median, mean ±SD)	Average of exam marks (thirtieths)* (median, mean ±SD)
	Group-work		
Never	20/21	22.0; 22.9 ±2.2	24.3; 24.4 ±1.9
Once	12/8	21.0; 22.0 ±1.9	23.8; 24.6 ±2.6
More than once	2/1	22.0; 22.0 ±2.0	24.0; 24.6 ±2.9
Not answered	2/0	21.0; 21.0 ±0.0	missing values
Comparison	$\chi^2 = 2.63$, $p = 0.45$	Kruskal Wallis, $p = 0.13$	Kruskal Wallis, $p = 0.9$
	Peer assessment		
Never	27/27	22.0; 22.4 ±2.1	24.0; 24.4 ±2.3
Once	3/3	23.0; 23.0 ±1.8	24.0; 24.7 ±2.4
More than once	0/0	no cases	no cases
Not answered	6/0	21.5; 21.5 ±0.6	23.7; 24.3 ±1.7
Comparison	$\chi^2 = 5.5$, $p = 0.06$	Kruskal Wallis, $p = 0.28$	Kruskal Wallis, $p = 0.99$

*Italian marking system (30 is the highest mark achievable, 18 is the lowest pass mark).

The perceptions of GW and PA, both pre- and post-course, are reported in Figure 2. For Q2, Q3, Q5 and Q7 the shift is statistically significant (Wilcoxon-signed-rank test; all $p < 0.01$). Significant correlations were found between the overall ratings for GW and PA both pre-course and post-course ($r_s = 0.36, p < 0.001$ and $r_s = 0.27, p = 0.03$, respectively). However, a Wilcoxon-signed-rank test showed no significant difference between the overall perception rating for GW and PA both pre-course and post-course ($p = 0.27$ and $p = 0.72$, respectively).

The comparison between the main GW and PA advantages and disadvantages perceived by the students, pre- and post-course, are reported in Table 4. The distribution of the main advantages perceived pre and post for GW was not significantly different ($\chi^2 = 11.2$, ns) whereas the distribution of the main disadvantages was significantly different ($\chi^2 = 18.9, p < 0.01$). The distribution of the main advantages pre and post for PA was significantly different ($\chi^2 = 13.4, p < 0.05$) whereas the distribution of the main disadvantage did not show any significant difference ($\chi^2 = 2.9$, ns).

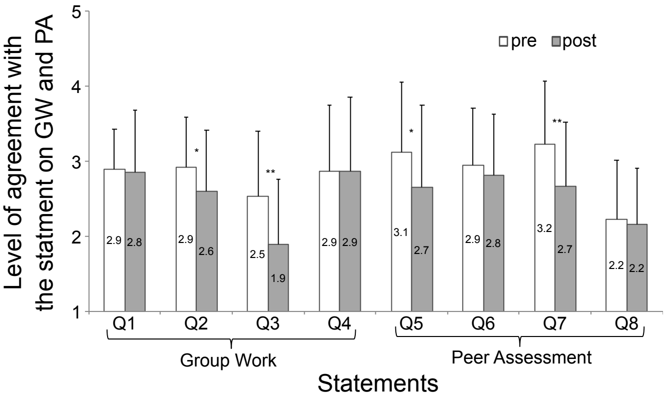

Figure 2.: *Mean and SD of rating of four questions about GW (Q1–Q4) and PA (Q5–Q8) asked to the students pre– and–post course (N = 66). Wilcoxon-signed-rank test: *p = 0.001: ** p < 0.001.*

Comparison Between Educators and Students perceptions about GW and PA

Educators' and students' perceptions (pre-course) of GW (Q1–Q4) and PA (Q5–Q8) are compared in Figure 3. Educators were more positive about Q1, Q2 and Q4 (Mann Whitney, all $p < 0.001$). For Q3 no difference was seen between educators and students (Mann Whitney, all $p = 0.60$). Perceptions about PA were also more positive in educators for Q5 (Mann Whitney, all $p < 0.05$) and more positive for students for Q8 (Mann Whitney, all $p < 0.001$). No differences were found between the two groups for Q6 and Q7 (Mann Whitney, $p = 0.90$ and 0.94, respectively). The differences between educators and students in Q1, Q2 and Q4 remained the same even when students' data after GW experience (post-course) was considered (Figure 2) (Mann Whitney, all $p < 0.001$), whereas the difference for Q3 became significant (Mann Whitney, $p < 0.001$) because the students' attitude moved from 2.5 to 1.9 (Figure 2). If students' post-course attitudes only were considered, then the difference between educators and students in Q5 would disappear (because students' attitude moved from 3.1 to 2.7), and the difference for Q7 would become significant (Mann Whitney, $p < 0.001$, because students' attitude moved from 3.2 to 2.7, Figure 2).

Table 4.: *Distribution (number [N] and percentage) of main advantage and disadvantage of GW and PA perceived by students (N = 66) pre– and post–course.*

Main advantage	N Pre	% Pre	N Post	% Post	Comparison Pre-Post	Main disadvantage	N Pre	% Pre	N Post	% Post	Comparison Pre-Post
						Group-work					
Improving subject knowledge	6	9.1	3	45		Strong personality of some participants can negatively affect collaboration	2	3.0	2	3.0	
Improving problem solving in clinical optometry	4	6.1	5	7.6		Participants' contributions are different	20	30.3	8	12.1	
Improving decision making in clinical optometry	0	0.0	1	1.5		Personality differences can create anxiety and stress	11	16.7	5	7.6	
Improving evidence-based approach in clinical optometry	10	15.2	18	27.3		Group-work reduce individual study time	20	30.3	41	62.1	
Improving collaboration aming peers	14	21.2	7	10.6	$\chi^2 = 11.2$ *ns*	Final assessment of group-work is more difficult	9	13.6	3	4.5	$\chi^2 = 18.9$, $p < 0.01$
Improving communication skills, discussion and debate	20	30.3	12	18.2		Other	2	3.0	5	7.5	
Improving problem solving skills	5	7.6	6	9.1		Not answered	2	3.0	2	3.0	
Improving planning skills	5	7.6	10	15.2							
Not answered	2	3.0	4	6.1							
						Peer assessment					
Encourage commitment	13	19.7	24	36.4		Stundents are less accurate and expert than lecturers	35	53.0	34	51.5	
Learning improves if students are involved in assessment criteria	10	15.2	6	9.1		Students have the bias to judge peers in the same way	14	21.2	20	30.3	
Students learn from success/failure of peers	12	18.2	2	3.0	$\chi^2 = 13.4$, $p < 0.05$	Students are not inclined to judge peers	3	4.5	2	3.0	$\chi^2 = 2.9$ *ns*
Developing criitical reflection	30	45.5	31	47.0		Students can give poor ranks for personal reasons	12	18.2	7	10.6	
Other	1	1.5	1	15		Other	1	1.5	1	1.5	
Not answered	0	0.0	2	3.0		Not answered	1	1.5	2	3.0	

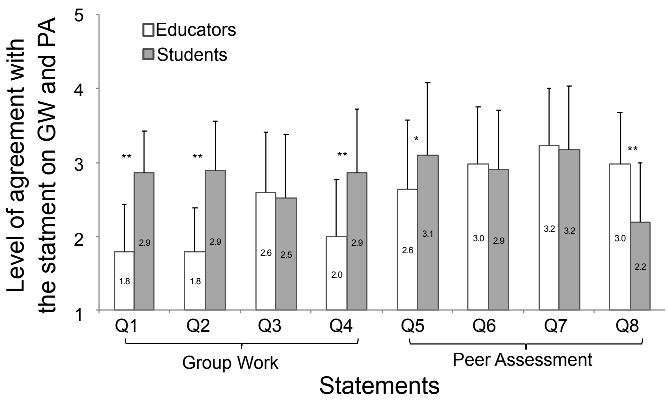

Figure 3.: *Comparison between educators (white bars) and students perceptions pre-course (grey bars) both for GW (Q1–Q4) and PA (Q5–Q8). Mann Whitney test: *p = 0.05: ** p < 0.001.*

Discussion

This study explored experience and attitudes toward GW and PA among Italian educators (Study 1) and students (Study 2) in the field of optometry higher education.

Study 1

Looking at the results in terms of experience, this study found that GW is used by two-thirds of Italian optometric educators. Two factors were significantly associated with the experience of GW: teaching experience and the type of teaching institution. Firstly, the longer the teaching experience, the more likely the educator is to use GW. It is possible that the longer time spent in education may have led the educators to become aware of the value of bringing GW into their practice, notwithstanding the fact that the additional time required for its preparation and implementation are generally considered an issue among educators (Gillies & Boyle, 2010).

Regarding the type of teaching institution, it was shown that educators in an academic environment had the lowest level of experience of GW: 13 out of 18 (72%) in the "Academia" group declared they had never used GW compared to 7% and 15% of "School" and "Both" groups. However, the mean ± *SD* of teaching experience resulted 7.4 ± 10, 16.1 ± 13.3 and 23.2 ± 11.5 for "Academia", School" and "Both", respectively, with a significant difference between the three groups (Kruskal Wallis test, $p < 0.01$). This led to the consideration that there is no direct effect of the type of teaching institution on the experience of GW, and rather it is the amount of teaching experience that may determine it. Interestingly, amongst interviewees who declared that they use GW none used this activity as a summative assessment tool. One explanation could be the fact that GW is considered more useful for students in formative assessment than in summative assessment (Frykedal & Chiriac, 2011). Another possibility may be linked to the rigid tradition in Italy to perform a classic written and oral assessment as formative assessment strategies.

The educators' experience with PA is even less common than GW and the use of PA as a summative assessment was negligible.

Regarding the educators' perception of the two pedagogical strategies studied, Figure 2 shows educators are more positive (lower scores) towards the GW than towards the PA (higher score). Lack of correlation between the overall perception rating for GW and PA as well as the difference between them demonstrates that the perception is different for the two strategies (Walker, 2001). The different educators' perception towards GW and PA is confirmed by the fact that they use the first tool more.

Analysis of advantages of GW (Table 2) showed that educators perceived GW as a strategy to develop "group abilities' such as communication skills (56%) and collaboration skills (13%) and not as a means for the students to acquire academic knowledge (14%) as already highlighted in literature (Frykedal & Chiriac, 2011). On the other hand, analysis of the main disadvantages of GW (Table 2) confirmed the evidence of literature (Le et al., 2018) that educators feel that participants' contribution to the GW may not be the same (60% of interviewees indicated this as the main disadvantage).

Finally, the majority of educators think that the main advantage of PA is the fact it allows critical reflection (60%), whilst in terms of disadvantages there is an equal split between factors linked to the quality of the assessment. In order to try to fight the barriers perceived by educators several tips have been suggested, such as introducing it gradually, providing mark-free rehearsal opportunities for the students, and providing really clear assessment criteria (Race et al., 2005). When PA is used for the first time a clear marking scheme should be provided at the beginning of the module and discussed with the students. Moreover, it may be introduced as a co-assessment strategy where the marks from the students are moderated by an average of the marks set by the staff (module leader and tutors). Interestingly, looking at the marks achieved in the final assessment of Study 2, no difference between the "pure" PA (only students) and staff PA was found ($t = 1.4, p = 0.18$). These results indicate that the disadvantages that students perceive are not reliable.

Study 2

The results of the second study highlight the fact that the optometry students attending the 3rd year had little experience with the pedagogical strategies investigated: 2 out of 3 students and 4 out of 5 students declared having never experienced GW and PA, respectively. This confirms the outcome that in Italian biomedical education experience of GW is not common (Lotti, 2015). As far as the perceptions of GW and PA are concerned, the results show that students had attitudes close to values in the middle of the scale (neutral attitudes) with no significant differences or positive correlations between them ($r_s = 0.36, p < 0.001$). However, being exposed directly to a teaching module in which GW and PA were used changed the attitudes of the students, which were improved for four out of the eight sub-scales studied. Specifically, amongst GW attitudes there was an enhancement of the perception that they will enjoy taking part GW (Q2) and that all members will be given the same possibility to contribute (Q3) (Figure 2). A very similar result was found by Walker (2001) for psychology students, which changed their attitudes after having experienced GW only for Q3. Students' attitudes to PA showed an improvement with Q5 (every student should take part) and Q7 (I will feel confident to mark). The only difference to the Walker (2001) study was that they found a difference for Q4, too.

Analysis of advantages of GW in the pre-course phase (Table 4) showed that students perceived that GW was a useful strategy to develop "group abilities" such as communication skills (30%) and collaboration skills (21%). However, the effect of direct experience of GW in the module attended only slightly changed their preferences, with an increase of a particular subject knowledge: the evidence-based approach in clinical optometry. This could be explained by the fact that this goal was a learning objective of the module and the GW activity was specifically set up to develop it. This confirms that GW can successfully be utilised to develop clinical skills (Frenk et al., 2010). Finally, concerning the PA, students declared that the major advantage was the ability to develop critical reflection (Table 4). In terms of disadvantages, the strongest one seemed to be a concern that PA was less accurate, and no change was perceived after having experienced PA.

In conclusion, although according the literature in the field GW and PA are considered very good strategies to improve teaching, the results of the present study have demonstrated that the use of these strategies in Italian optometric higher education is quite limited. However, the study has also demonstrated that Italian optometry educators have positive attitudes towards "social" teaching strategies, especially for GW. Furthermore, optometry students showed improved attitudes towards these strategies once exposed to them. Overall, the results of the study open up the possibility of integrating "social" teaching strategies to improve the effectiveness of optometry education.

Conflict of interest

The authors declare that they have no conflict of interest related to this paper.

References

Barrows, H., & Pickell, G. (1991). *Developing Clinical Problem Solving Skills: A Guide to More Effective Diagnosis and Treatment*. WW Norton.

Benati, S., & Chiari, G. (2008). *I meccanismi dell'apprendimento cooperativo: un approccio di scelta razionale.* Dipartimento di sociologia e ricerca sociale quaderni.

Bennett, N., & Dunne, E. (1992). *Managing Classroom Groups.* Simon & Schuster Education.

Biggs, J., & Tang, C. (2011). *Teaching for Quality Learning at University.* Open University Press.

Boud, D., Cohen, R., & Sampson, J. (1999). Peer learning and assessment. *Assessment and Evaluation in Higher Education*. https://doi.org/10.1080/0260293990240405

Bruffee, K. A. (1995). Sharing Our Toys: Cooperative Learning Versus Collaborative Learning. *Change: The Magazine of Higher Learning*. https://doi.org/10.1080/00091383.1995.9937722

Carless, D., Joughin, G., & Liu, N. (2006). *How assessment supports learning: Learning-oriented assessment in action.* Hong Kong University Press.

Comoglio, M. (1999). *Il cooperative learning. Strategie di sperimentazione.* (Ed. Gruppo Abele., Ed.). Ed. Gruppo Abele.

Conway, R., Kember, D., Sivan, A., & Wu, M. (1993). Peer Assessment of an Individual's Contribution to a Group Project. *Assessment & Evaluation in Higher Education*. https://doi.org/10.1080/0260293930180104

Dochy, F., Segers, M., & Sluijsmans, D. (1999). The Use of Self-, Peer and Co-assessment in Higher Education: A review. *Studies in Higher Education*. https://doi.org/10.1080/03075079912331379935

Falchikov, N. (2007). The place of peers in learning and assessment. In D. Boud & N. Falchikov (Eds.), *Rethinking assessment in higher education: Learning for the longer term* (pp. 128–143). Routledge.

Falchikov, N., & Goldfinch, J. (2000). Student peer assessment in higher education: A meta-analysis comparing peer and teacher marks. *Review of Educational Research*. https://doi.org/10.3102/00346543070003287

Forsell, J., Forslund Frykedal, K., & Hammar Chiriac, E. (2020). Group Work Assessment: Assessing Social Skills at Group Level. *Small Group Research*. https://doi.org/10.1177/1046496419878269

Freeman, M. (1995). Peer Assessment by Groups of Group Work. *Assessment & Evaluation in Higher Education.* https://doi.org/10.1080/0260293950200305

Frenk, J., Chen, L., Bhutta, Z. A., Cohen, J., Crisp, N., Evans, T., Fineberg, H., Garcia, P., Ke, Y., Kelley, P., Kistnasamy, B., Meleis, A., Naylor, D., Pablos-Mendez, A., Reddy, S., Scrimshaw, S., Sepulveda, J., Serwadda, D., & Zurayk, H. (2010). Health professionals for a new century: Ttransforming education to strengthen health systems in an interdependent world. https://doi.org/10.1016/S0140-6736(10)61854-5

Fry, H., Ketteridge, S., & Marshall, S. (2008). *A handbook for teaching and learning in higher education: Enhancing academic practice.* Routledge. https://doi.org/https://doi.org/10.4324/9780203891414

Frykedal, K. F., & Chiriac, E. H. (2011). Assessment of students' learning when working in groups. *Educational Research*. https://doi.org/10.1080/00131881.2011.598661

Galton, M., & Williamson, J. (1992). *Group Work in the Primary Classroom.* Routledge. https://doi.org/https://doi.org/10.4324/9780203392713

Gaudet, A. D., Ramer, L. M., Nakonechny, J., Cragg, J. J., & Ramer, M. S. (2010). Small-group learning in an upper-level university biology class enhances academic performance and student attitudes toward group work. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0015821

Gillies, R. M., & Boyle, M. (2010). Teachers' reflections on cooperative learning: Issues of implementation. *Teaching and Teacher Education*. https://doi.org/10.1016/j.tate.2009.10.034

Hammar Chiriac, E. (2014). Group work as an incentive for learning – students' experiences of group work. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2014.00558

Hassanien, A. (2006). Student experience of group work and group assessment in higher education. *Journal of Teaching in Travel and Tourism*. https://doi.org/10.1300/J172v06n01_02

Hrynchak, P. K., & Spafford, M. M. (2015). *Optometry Students' Attitudes about Team-Based Learning* (tech. rep.).

Hwong, N. C., Caswell, A., Johnson, D. W., & Johnson, R. T. (1993). Effects of cooperative and individualistic learning on prospective elementary teachers' music achievement and attitudes. *Journal of Social Psychology*. https://doi.org/10.1080/00224545.1993.9712118

Janssen, J., Kirschner, F., Erkens, G., Kirschner, P. A., & Paas, F. (2010). Making the black box of collaborative learning transparent: Combining process-oriented and cognitive load approaches. https://doi.org/10.1007/s10648-010-9131-x

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*. https://doi.org/10.3102/0013189X09339057

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative Learning: Improving University Instruction by Basing Practice on Validated Theory. *Journal of Excellence in College Teaching.* https://doi.org/10.1080/19397030902947041

Le, H., Janssen, J., & Wubbels, T. (2018). Collaborative learning practices: teacher and student perceived obstacles to effective student collaboration. *Cambridge Journal of Education*. https://doi.org/10.1080/0305764X.2016.1259389

Leach, L., Neutze, G., & Zepke, N. (2001). Assessment and empowerment: Some critical questions. *Assessment and Evaluation in Higher Education*. https://doi.org/10.1080/02602930120063457

Lotti, A. (2015). Problem based learning in Italian universities. *Journal on Medical Education and Practice*, *15(1), 5-1*(1), 5–12.

Lovie-Kitchin, J. (1991). Problem-based learning in optometry. In D. Boud & F. Feletti (Eds.), *He challenge of problem-based learning* (pp. 203–210). St. Martin's Press.

Ortiz, A. E., Johnson, D. W., & Johnson, R. T. (1996). The effect of positive goal and resource interdependence on individual performance. *Journal of Social Psychology*. https://doi.org/10.1080/00224545.1996.9713998

Panitz, T. (1999). Collaborative versus Cooperative Learning: A Comparison of the Two Concepts Which Will Help Us Understand the Underlying Nature of Interactive Learning. http://files.eric.ed.gov/fulltext/ED448443.pdf

Pfaff, E., & Huddleston, P. (2003). Does It Matter if I Hate Teamwork? What Impacts Student Attitudes toward Teamwork. *Journal of Marketing Education*. https://doi.org/10.1177/0273475302250571

Race, P. (2001). *A briefing on self, peer and group assessment.* LTSN generic centre.

Race, P. (2007). *The lecturer's toolkit: a resource for developing assessment, learning and teaching.* Routledge. https://doi.org/https://doi.org/10.4324/9780203968529

Race, P., Brown, S., & Smith, B. (2005). *500 tips on assessment.* Routledge. https://doi.org/https://doi.org/10.4324/9780203307359

Sadler, P. M., & Good, E. (2006). The impact of self- And peer-grading on student learning. *Educational Assessment*. https://doi.org/10.1207/s15326977ea1101_1

Thomas, G., Martin, D., & Pleasants, K. (2011). Using self- and peer-assessment to enhance students ' future-learning in higher education . *Journal of University Teaching Learning Practice*.

Walker, A. (2001). British Psychology Students' Perceptions of Group-Work and Peer Assessment. *Psychology Learning & Teaching*. https://doi.org/10.2304/plat.2001.1.1.28

Weisinger, H. S., & Prideaux 3, D. (2011). Modernizing Optometric Education in Australia: Ideas from Medical Education. *Optometric Education*.

White, F., Lloyd, H., & Goldfried, J. (2007). Evaluating student perceptions of group work and group assessment. In A. Brew & J. Sachs (Eds.), *Transforming a university: The scholarship of teaching and learning in practice* (pp. 71–80). Sydney University Press.

Appendix A – Educator's and Student's Questionnaires

1. Educator's Information:

Gender: M/F Age:_________ Years of teaching____________

Teaching institution/s__________________________ Module taught:_________________

2. Educator's experience and perceptions about GW:

Have you ever used GW in a module delivery as a formative tool? Never ❒ Once ❒ More than once ❒

If you have used GW at least once, did you use it also as a summative assessment tool? Yes ❒ No ❒

Please rate your level of agreement with the following statements according this scale 1 = agree very much, 2 = agree, 3 = not sure, 4 = disagree, 5 = disagree very much:

-Q1: I think GW is a good idea for the students___________

-Q2: I think that students will enjoy taking part in GW___________

-Q3: I think that all students in the group will be given equal opportunity to contribute___________

-Q4: I think that students will learn more about the subject matter working in a group than they would if they worked individually___________

Among the following, please indicate the most important advantage of GW:

❒ Improving theoretical knowledge of the subject

❒ Improving peer collaboration skills

❒ Improving communication, discussion, and debating skills

❒ Improving problem solving skills

❒ Improving plan management

❒ Other (please specify)_________

Among the following, please indicate the most important disadvantage of GW:

❒ Strong personality of one or more students in the group can negatively affect collaboration in the group

❒ Contribution of students may be unequal, and some may not engage at all

❒ Conflicting personalities within the group can create anxiety, stress and hostility

❒ GW can reduce time for individual study

❒ Other (please specify)_________

3. Educator's experience and perceptions about PA:

Have you ever used PA in a module delivery as a formative tool? Never ❒ Once ❒ More than once ❒

If you have used PA at least once, did you use it also as a summative assessment tool? Yes ❒ No ❒

Please rate your level of agreement with the following statements according this scale 1 = agree very much, 2 = agree, 3 = not sure, 4 = disagree, 5 = disagree very much:

-Q5: I think that students should take part in assessing their peers___________

-Q6: I think that students will be able to assign grades to their peers in a responsible manner___________

-Q7: I think that students feel comfortable when making PA___________

-Q8: I think that students will make a fair and responsible assessment of their peers___________

Among the following, please indicate the most important advantage of PA:

❒ PA encourages commitment and involvement of students

❒ Student learning improves if students are involved in assessment criteria

❒ Students can learn from success or unsuccessful performance of peers

❒ PA improves critical reflection

❒ Other (please specify)_________

Among the following, please indicate the most important disadvantage of PA:

❒ Students are less objective and have less experience than educators

❒ Students are uncomfortable when judging their peers

❒ Students may be inclined to judge their peers too highly in order to keep them happy

❒ Students may discriminate peers for personal reasons (competition, envy, etc.)

❒ Other (please specify)_________

Figure A.1.: *Summarised version (translated from Italian) of Educator's questionnaire used in the survey.*

1. Student's Information:

Course number _________Gender: M/F Age:_________ average of exams marks achieved in the academic career up to date _________

2. Student's experience and perceptions about GW:

Have you ever participated to a GW in any academic module? Never ❒ Once ❒ More than once ❒

Please rate your level of agreement with the following statements according this scale 1 = agree very much, 2 = agree, 3 = not sure, 4 = disagree, 5 = disagree very much:

-Q1: I think GW is a good idea___________

-Q2: I think that I will enjoy taking part in GW___________

-Q3: I think that all the members of the group will be given equal opportunity to contribute___________

-Q4: I think that I will learn more about the subject matter working in a group than working by myself.___________

Among the following, please indicate the most important advantage of GW:

❒ Improving theoretical knowledge of the subject

❒ Improving peer collaboration skills

❒ Improving communication, discussion, and debating skills

❒ Improving problem solving skills

❒ Improving plan management

❒ Improving problem solving skills in clinical optometry

❒ Improving decision making skills in clinical optometry

❒ Improving evidence-based approach in clinical optometry

❒ Other (please specify)_________

Among the following, please indicate the most important disadvantage of GW:

❒ Strong personality of one or more students in the group can negatively affect collaboration in the group

❒ Contribution of students may be unequal, and some may not engage at all

❒ Conflicting personalities within the group can create anxiety, stress and hostility

❒ GW can reduce time for individual study

❒ Other (please specify)_________

3. Student's experience and perceptions about PA:

Have you ever participated to PA in any academic module? Never ❒ Once ❒ More than once ❒

Please rate your level of agreement with the following statements according this scale 1 = agree very much, 2 = agree, 3 = not sure, 4 = disagree, 5 = disagree very much:

-Q5: I think that students should take part in assessing their peers___________

-Q6: I think that 3rd-year student students will be able to assign grades to their peers in a responsible manner ___________

-Q7: I think that I will feel comfortable when making PA___________

-Q8: I think that I will make a fair and responsible assessment of my peers___________

Among the following, please indicate the most important advantage of PA:

❒ PA encourages commitment and involvement of students

❒ Student learning improves if students are involved in assessment criteria

❒ Students can learn from success or unsuccessful performance of peers

❒ PA improves critical reflection

❒ Other (please specify)_________

Among the following, please indicate the most important disadvantage of PA:

❒ Students are less objective and have less experience than educators

❒ Students are uncomfortable when judging their peers

❒ Students may be inclined to judge their peers too highly in order to keep them happy

❒ Students may discriminate peers for personal reasons (competition, envy, etc.)

❒ Other (please specify)_________

Figure A.2.: *Summarised version (translated from Italian) of the student's questionnaire used in the survey.*

Refitting a patient with pellucid marginal degeneration from a corneal rigid gas permeable lens to scleral lens

Eilin Lundanes and Jörgen Gustafsson

National Centre for Optics, Vision and Eye Care; Department of Optometry, Radiography and Lighting Design. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway.

Received October 14, 2019, accepted June 16, 2020.
Correspondence: eilin.lundanes@usn.no

Abstract

This case report describes a 66 years old male patient with pellucid marginal degeneration (PMD). The patient had fallen out of a regular follow-up scheme and presented with a poorly fitting corneal rigid lens that he had worn for almost five years. Correction had failed to improve vision in the left eye, so the patient wears a contact lens in his right eye only. Scleral lenses vault over the cornea, the tear layer between the lens and the cornea masks corneal irregularities and are a good correction option for corneal ectasias. This patient was fitted with an Onefit scleral lens that provided good visual acuity and comfort. Lens handling was no obstacle to this patient. A heart surgery postponed the first follow-up examination. Follow-up examination 8 months after the refit resulted in no changes of lens parameters as the fitting was still acceptable and the patient was happy. Attention to the inferior limbal clearance will be the focus at the next follow-up in 6 months' time.

Keywords: Pellucid marginal degeneration, corneal rigid lens, corneal irregularities, scleral lens

Sammendrag

Denne kasus rapporten beskriver en 66 år gammel mannlig pasient med pellusid marginal degenerasjon (PMD). Pasienten hadde ikke hatt jevnlige rutinekontroller, og han ankom klinikken med en fem år gammel formstabil korneal linse som passet svært dårlig. Kontaktlinse bæres kun på pasientens høyre øye, da venstre øye ikke oppnår funksjonsforbedring med korreksjon. Sklerallinser hvelver over kornea, og tårelinsen mellom linsen og kornea maskerer korneale irregulæriteter. Det gjør at denne typen linser er et godt alternativ til korreksjon av korneale ektasier. Pasienten ble tilpasset med en Onefit sklerallinse som ga god visus og komfort. Håndtering av linsen var ingen utfordring for pasienten. En hjerteoperasjon utsatte første oppfølgingstime. Oppfølgingstimen 8 måneder etter tilpassing viste akseptabel linsetilpassing og fornøyd pasient, og det ble ikke gjort noen endring av linseparametere. Neste etterkontroll foretas om 6 måneder, med spesielt fokus på tilpassingen over limbus.

Nøkkelord: Pellusid marginal degenerasjon, korneal ektasi, retilpassing, korneal linse, sclerallinse

Background

Pellucid marginal degeneration (PMD) is a rare bilateral, asymmetric, non-inflammatory corneal ectasia that most commonly occurs in the inferior part of the cornea. A narrow band of corneal thinning is usually present in areas from around 4 o'clock to 8 o'clock, with 1-2 mm of unaffected cornea between the thinning and limbus (Martinez-Abad & Pinero, 2019). Central corneal thickness is normal, and an anterior displacement of the cornea occurs directly above the band of thinning. The vertical meridian above the area of thinning is flat; hence, irregular "against-the-rule" astigmatism is usually present. These corneal changes result in a classical "crab-claw" topography map, also referred to as "kissing doves" or "butterfly" patterns (Jinabhai et al., 2011). Literature suggests a slightly higher incidence in men, but shows no ethnical or geographical predisposition (Jinabhai et al., 2011), nor familial inheritance (Martinez-Abad & Pinero, 2019). Systemic diseases associated with eye rubbing and progressive connective tissue diseases might be associated with PMD, this is yet to be confirmed (Martinez-Abad & Pinero, 2019).

PMD can easily be confused with other bilateral corneal ectatic disorders, such as keratoconus and keratoglobus. The etiology of these ectasias is not fully understood. Possibly these are not three different diseases, but rather different clinical presentations of the same underlying disease (Martinez-Abad & Pinero, 2019). Keratoconus is the most common corneal ectasia. It usually occurs earlier in life (puberty) and progresses more rapidly than PMD. With the cone situated away from the corneal centre and a topographic "crab-claw" pattern, inferior keratoconus resembles PMD (Koc et al., 2018). However, in all clinical cases of keratoconus, Fleisher ring and Vogt's striae are present. In moderate and severe cases apical corneal scarring, Rizutti's phenomenon and Munson's sign also are present in keratoconus. All these signs are absent in PMD (Jinabhai et al., 2011).

Spectacles and soft contact lenses work well in early stages of PMD. As the condition progresses, and irregular astigmatism and corneal irregularity occur, rigid gas permeable (RGP) contact lenses are usually required. Hybrid contact lenses, piggyback, large-diameter RGP, bitoric RGP or reverse-geometry RGP might be needed to avoid excessive inferior edge standoff (Asena & Altınörs, 2016; Jinabhai et al., 2011; Rathi et al., 2016). Several authors have reported successful fitting of scleral lenses for patients with advanced PMD (Asena & Altınörs, 2016; Biswas et al., 2000; Ozek et al., 2018; Pullum & Buckley, 1997; Rathi et al., 2016). Scleral lenses vault over the entire cornea and rest on the sclera. The tear reservoir under the lens masks the corneal irregularity and increases visual acuity and comfort (Otchere et al., 2017). A variety of terminology has been in use to describe various modalities of scleral lenses. Terms like mini-scleral and full scleral lenses, differentiate lenses with a total diameter up to 6 mm larger than horizontal visible iris diameter (HVID) from lenses with larger total diameters. In "An official guide to scleral lens terminology" published in Contact Lens and Anterior Eye recently, Michaud et al. (2019) suggest avoiding this terminology. All lenses that vault entirely over cornea and limbus are to be called scleral lenses (Michaud et al., 2019).

The fitting of scleral lenses on corneal ectasias has grown rapidly over the past few years due to improved lens designs, development of highly oxygen permeable lens materials, and increased awareness and acceptance by ophthalmologists around the world (Asena & Altınörs, 2016; Otchere et al., 2017). There are potential contraindications to consider upon fitting scleral lenses. Fadel and Kramer (2019) have recently done a literature review, resulting in the provision of guidelines on how to proceed caution in certain conditions. According to the authors, potential contraindications for scleral lens wear are significant corneal endothelial abnormalities, glaucoma or following glaucoma therapy, and overnight wear.

The approach to fitting scleral lenses varies between manufacturers, and it is useful to read the fitting guide for the specific lens before fitting. In the case presented, the fitting guide and trial set chosen were for Onefit designed by Blanchard Lab

Canada, manufactured by Multilens, Sweden (Blanchard Contact Lenses, 2018).

Case presentation

This case presents a male born in 1952, who came to our clinic in August 2018, referred by a colleague. For several reasons he was lost to follow-up for almost five years. The patient was diagnosed with bilateral PMD in 2012 and wore spectacles and soft contact lenses successfully until he was about 50 years of age. Eventually he was fitted with corneal rigid lenses in 2013. Correction failed to improve vision in the left eye, and lens wear in this eye was discontinued.

The patient presented with a Rose K2 IC contact lens (Menicon Co, Nagoya, Japan) received in February 2014. Wearing time was approximately 15 hours a day. Without this lens, the patient felt he was blind. He wore reading spectacles over the contact lens, but he still noticed shadows on letters when reading. Despite a very old contact lens, the patient did not experience ocular redness, or discomfort, or problems with the lens.

The patient came in wearing his Rose K2 IC lens. Initially, visual acuity, over-refraction and assessment of the lens fitting with the slit-lamp were performed. After lens removal, corneal topography with Medmont M700 (Medmont International, Nunawading, Australia) and assessment of the anterior segment using a slit lamp with and without fluorescein were done. The fitting of a scleral lens to the right eye only was completed according to the Onefit fitting guide. Assessment of the fit was repeated after one hour of wear, and over-refraction was done. In addition to the procedures already mentioned, anterior segment OCT with Zeiss Cirrus (Zeiss MedTec AG, Oberkochen, Germany) was used for lens assessment upon follow-up.

Results

Preliminary tests

Assessment of the habitual contact lens fit using the slit lamp and fluorescein: The lens decentered inferiorly over limbus with no visible movement. The inferior lens edge was stuck in the inferior conjunctiva. The fitting was flat centrally, with a broad edge lift nasally, temporally and superiorly. Table 1 shows preliminary measurements and results of examination of the anterior segment after lens removal using the slit-lamp and Efron grading scale.

Table 1.: *Results of preliminary tests.*

Uncorrected distance visual acuity (VA)	1.4 logMAR	
Habitual correction (Rose K2) IC	Base curve	6.55 mm
	Diameter	11.8 mm
	Edge	Incline +1.5
	Power	−6.50 D
Habitual distance VA	0.36 logMAR	
Over-refraction	−1.00 DS, 0.1 logMAR	
Lids	No blepharitis or Meibomian gland dysfunction	
Bulbar redness	E 2.0 (in all quadrants)	
Limbal redness	E 1.0	
Neovascularization	E 2.0 at 2-4 o'clock and 7-8 o'clock. Ghost vessels at 10-2 o'clock.	
Cornea	Visible thickness irregularities, with a band of thinning inferiorly.	
	Clear cornea.	
	Polymegathism: E 1.5	
With fluorescein	No corneal staining.	
	Conjunctival staining in the area where the edge of the habitual lens had been sitting.	

Topography: Figure 1a shows the axial topography map of the right eye performed with Medmont M700 (directly after removal of the Rose K lens). Four topography measurements showed repeatable results. The topography confirms an irregular cornea with flatter curvatures superiorly and the steeper curvatures inferiorly, and the surface indexes confirm large irregularities.

Keratometry readings in diopters: 45.91 @ 56° / 55.06 @ 146°

Keratometry readings in millimetres: 7.35 @ 56° / 6.24 @ 146°

The elevation difference between the highest and the lowest point of the cornea was just over 400 μm, seen in Figure 1b.

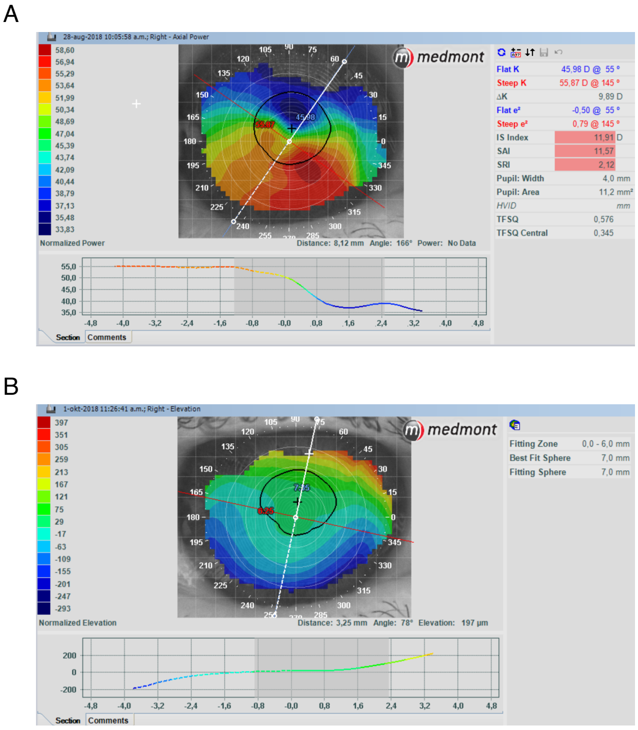

Figure 1.: *Corneal Topographic plot directly after lens removal of the corneal rigid lens RE.*

Scleral lens fitting

We used a trial lens set of Onefit with total diameter of 14.9mm. The fitting guide recommends base curve selection to be equivalent to the flattest K-reading. The trial lens parameters are shown in Table 2, and Table 3 shows results one hour after insertion.

Table 2.: *Onefit trial lens parameters.*

Base curve	7.30 mm
Diameter	14.9 mm
Edge	Standard
Power	−4.00 D

Table 3.: *Assessment of lens fit one hour after insertion.*

Distance VA	0.1 logMAR
Over-refraction	+0.50 DS, no change in VA
Near VA (with add +2.00)	0.1 logMAR
Central clearance over the pupil	≈ 300 μm
Clearance inferiorly, over the cone	≈ 100 μm

The limbal clearance seemed sufficient, and the edge and edge lift were good, with no sign of blanching or impingement. The fit was considered acceptable the contact lens shown in Table 4 was ordered.

Table 4.: *Onefit lens parameters ordered for patient.*

Onefit scleral lens in material	Boston XO (blue handling colour)
Base curve	7.30 mm
Diameter	14.9 mm
Edge	Standard
Power	−3.50 D

When the lens arrived, the patient came in to the clinic to learn proper lens handling and care. He had no trouble inserting the lens using an insertion cup, nor removing the lens using a regular lens remover for rigid gas permeable contact lenses. The patient was instructed to rub the lens in a standard multipurpose solution for rigid gas-permeable lens materials for 20 seconds, rinse the lens in the same solution and fill the lens case with the solution prior to placing the lens into the lens case for disinfection overnight. For lens insertion, the patient was instructed to fill the lens with unpreserved single-dose saline.

Follow-up examination

Due to a heart surgery, the first follow-up examination followed 8 months after re-fitting. During this time leaning forward to insert the lens had been impossible, and the patient had only started wearing the scleral lens approximately 3 weeks prior to the follow-up examination. The patient reported excellent comfort and vision with the scleral lens, with no complaints. On the day of follow-up the lens had been in the eye for approximately 7 hours. Acuity results are shown in Table 5.

Table 5.: *Assessment of lens fit approximately 7 hours after insertion.*

VA with scleral lens	0.3 logMAR
Over-refraction	−1.00 DS, 0.1 logMAR

Figure 2 shows excellent lens centration and overall lens diameter. The lens extends a little more than 1.25 mm outside of limbus, which corresponds with the fitting guide recommendations. The landing zone and edge (Figure 2) align well with the sclera with no signs of impingement or blanching, nor does the lens move or allow air bubbles to enter under the edge.

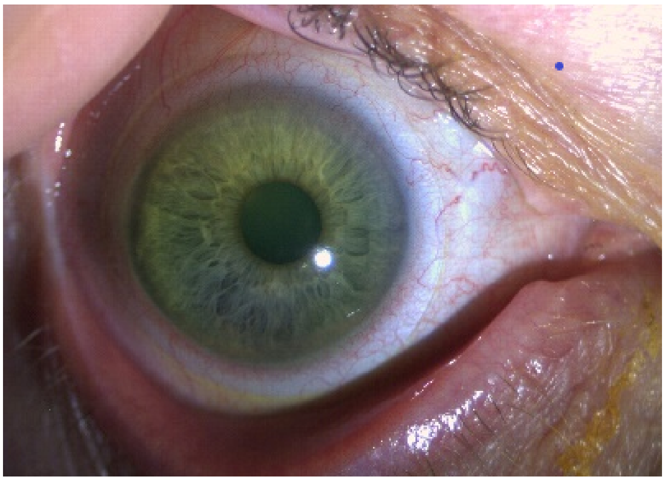

Figure 2.: *Lens fit in white light showed excellent centration, good overall diameter and well-fitting edge.*

Figure 3 shows the assessment of the apical clearance using the slit lamp with white light and fluorescein in the lens bowl. Central clearance is approximately 350 μm at centre of the pupil. The clearance increases superiorly. Inferiorly, at the point where the cornea is bulging out, the corneal clearance is approximately 50 μm.

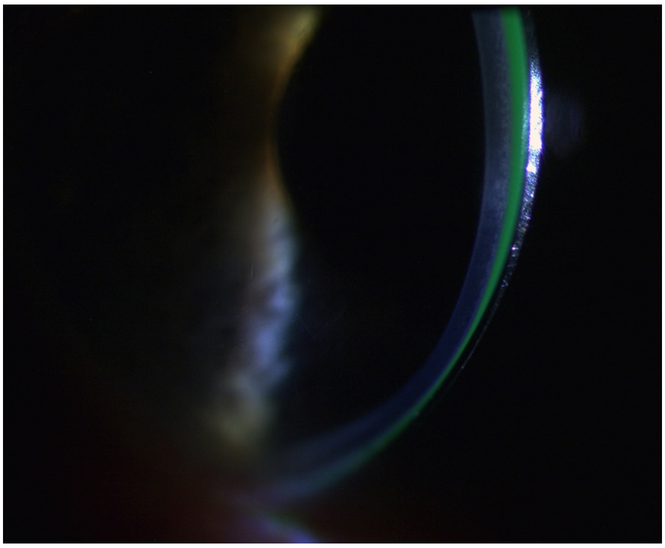

Figure 3.: *Scleral lens fit seen with an optic section. Note the relatively high central clearance and the minimal inferior clearance over the highest point of the cornea.*

Anterior segment OCT (with Zeiss Cirrus) confirms these results. The OCT image of central clearance (see Figure 4) indicates a central clearance of 379 μm. Figure 5 shows a clearance of 49 μm at the apex of the cone.

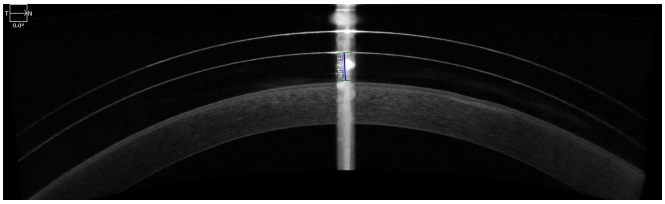

Figure 4.: *OCT central clearance: 379 µm.*

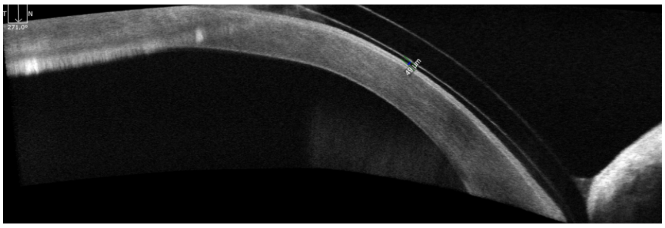

Figure 5.: *OCT clearance at the cone: 49 µm.*

The anterior segment was mainly unchanged from the initial fit, but with less bulbar redness than at the initial visit (E1.0 vs E2.0). Superficial corneal staining close to the inferior limbus from 5 to 7 o'clock, indicates a slight lens touch in this area. This corresponds with the OCT picture in Figure 6.

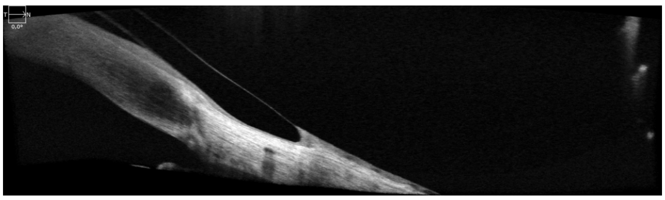

Figure 6.: *OCT the edge sinks nicely into the conjunctiva without compression of structures. The lens seems to touch the limbal area slightly in this section.*

Discussion

This case describes a patient diagnosed with PMD several years ago, who had been wearing a Rose K2 IC large diameter RGP contact lens for several years. The patient presented with a 4 year old lens that he was happy with, except for some shadowing on letters when reading. Examination revealed an unacceptable lens fit. The excessive lens decentration resulted in a lens that was stuck in the inferior conjunctiva. This was probably the reason for conjunctival staining in this area, the bulbar redness, and the excessive edge lift in the three other quadrants. This is the opposite of what literature usually reports as a challenge with corneal RGP lenses on advanced PMD patients. Excessive inferior edge stand-off is more common (Asena & Altınörs, 2016; Jinabhai et al., 2011; Rathi et al., 2016). The inferior position of apex of cornea might be one of the reasons for the decentration. It is also likely that the lens parameters had changed with time, as RGP materials tend to deteriorate. Lens thickness reduces with time, making the lens subject to warpage. Lens binding is also common with old lenses (Efron, 2018). Refitting with a new Rose K2 lens or another corneal RGP contact lens designed for irregular corneas could have been an option for this patient. Two aspects lead to the choice of a scleral lens. Firstly, lens decentration is easier to overcome with a larger lens as opposed to a smaller lens. Secondly, topography showed a corneal elevation difference of approximately 400 μm. This would increase the risk of a small lens rocking on the corneal apex. Management of corneal height differences is easier with a scleral lens as the lens vaults over the entire cornea. As several authors have reported successful fitting of scleral lenses for patients with advanced PMD (Biswas et al., 2000; Ozek et al., 2018; Pullum & Buckley, 1997; Rathi et al., 2016), we decided to try refitting the patient. There are several scleral lens designs available, and we decided on Onefit as the trial set was already available and familiar to the clinicians.

The fitting procedure was done by following the Onefit fitting guide, apart from selection of the total diameter. The fitting guide recommends selecting the total diameter from the patient's HVID (Blanchard Contact Lenses, 2018). HVID was not measured in this case, and the trial set available only contained lenses with diameter 14.9 mm. However, this diameter was perfect. Upon insertion, the central clearance was large, but these kinds of lenses will recess during the day. During a full day of wear, a recess of 100 μm is expected (Blanchard Contact Lenses, 2018). The fitting guide recommends assessing the lens fit at application, after 30 minutes, and after 4 hours of lens wear (Blanchard Contact Lenses, 2018). During the fitting process in our case, the fit was reassessed after 1 hour only. The time needed for a scleral lens to settle is highly individual, and the average loss of central corneal clearance after one hour was 34 ± 48 μm (Otchere et al., 2017). With this in mind, our case of 100 μm clearance of the cone might suggest that the clearance was on the small side. However, the follow-up examinations were performed in the afternoon, several hours after lens insertion, and as shown, the lens did not touch the highest point of the cornea. The clearance in the central and superior part of cornea was a little larger than recommended. With irregular corneas there will be a wide variation in clearance across the cornea (Walker et al., 2016), as seen in this case.

Limbal clearance is another important factor to consider in scleral lens fitting. Extensive clearance reduces the Dk/t, which increases the risk of hypoxia. On the other hand, touch in this area should be avoided, as it may affect the limbal stem cells (Walker et al., 2016). A limbal clearance of 100 μm is often striven for (van der Worp, 2015), but the Onefit fitting guide recommends to keep it as minimal as possible without touch. Fluorescein is not visible when the clearance is less than 25 μm, but staining in the limbal area is an indication of touch (Blanchard Contact Lenses, 2018). In addition to the staining found along the inferior part of the limbus, OCT confirmed slight limbal touch. This might be dealt with in two ways; either order lenses with "Extra limbal clearance", which will increase the limbal clearance by 50 μm without affecting the lens behavior on the eye, or increase the total diameter of the lens (Blanchard Contact Lenses, 2018). If the lens fits well elsewhere, Walker et al. (2016) usually accept less than 20% or limbal touch. For this reason, we decided to go ahead without any changes. The limbal clearance and staining must be monitored closely and should be checked at the next follow-up visit. The edge, on the other hand, was fitting well with no signs of being too flat or too tight.

From the initial fit to the follow-up examination, the visual acuity dropped, and an over-refraction of −1.00 D improved the visual acuity back to baseline. The reason for this could be inaccurate over-refraction when fitting. The initial examination lasted a long time. A tired and unfocused patient could influence the refraction. Research found that lens settling does not affect over-refraction and visual acuity (Bray et al., 2017). Large corneal clearance will affect visual acuity (Fadel, 2019). The corneal clearance varies largely across the cornea of this patient. If the patient focused through a slightly different part of the lens on the follow-up examination, this might have affected the visual acuity. Corneal oedema is a complication of scleral lens wear that also affect over-refraction and visual acuity. Studies have failed to show clinical significant oedema following daily wear of scleral lenses in normal corneas, but sub-clinical levels of edema might occur (Fadel, 2019). The patient did not present with other signs of corneal oedema, but attention to the corneal wellbeing, and the state of the endothelium in particular (Fadel & Kramer, 2019) is important at all future follow-up examinations.

The most common reason for discontinuation of scleral lens wear is issues with lens handling (Asena & Altınörs, 2016). Educating the patient well is important, as well as patient motivation. In this case, the patient was highly motivated, as he felt blind without a lens. After recovering from the heart surgery, lens handling was no issue either. An ophthalmologist diagnosed the patient with PMD in 2013, and the findings in the anterior segment of this patient resemble characteristics of PMD. However, detailed anterior and posterior elevation maps and full pachymetry maps with thickness data would add valuable information to the state of the condition of the patient, and possible progression (Belin et al., 2011). This will be included in future follow-up of this patient. Examination of the posterior segment was not included in this case report. As glaucoma is a potential contraindication to scleral lens wear (Fadel & Kramer, 2019), future follow-up examinations should also include procedures such as dilated fundus examination, posterior segment OCT, intraocular pressure and perimetry. With the history of being lost to follow-up for several years, it is crucial to emphasize the importance of regular 6-monthly follow-up examinations to this patient.

Conclusion

A patient with PMD presented with a poorly fitting Rose K2 IC lens and was successfully refitted with a Onefit scleral lens. Lens handling was no obstacle, and the patient was happy with vision and comfort. The next follow-up visit will take place 6 months from the last examination, with specific attention to the corneal status, limbal clearance and the posterior segment.

References

Asena, L., & Altınörs, D. D. (2016). Clinical outcomes of scleral misa lenses for visual rehabilitation in patients with pellucid marginal degeneration. *Contact Lens and Anterior Eye*, *39*(6), 420–424. https://doi.org/https://doi.org/10.1016/j.clae.2016.06.010

Belin, M. W., Asota, I. M., Ambrosio, R., & Khachikian, S. S. (2011). What's in a name: Keratoconus, pellucid marginal degeneration, and related thinning disorders. *American Journal of Ophthalmology*, *152*(2), 157–162.e1. https://doi.org/10.1016/j.ajo.2011.03.028

Biswas, S., Brahma, A., Tromans, C., & Ridgway, A. (2000). Management of pellucid marginal corneal degeneration. *Eye*, *14*, 629–634.

Blanchard Contact Lenses. (2018). http://blanchardlab.com/wp-content/uploads/2018/09/Onefit-Fittingguide-08-13-18-Web.pdf

Bray, C., Britton, S., Yeung, D., Haines, L., & Sorbara, L. (2017). Change in over-refraction after scleral lens settling on average corneas. *Ophthalmic and Physiological Optics*, *37*(4), 467–472. https://doi.org/10.1111/opo.12380

Efron, N. (2018). *Contact lens practice* (Third edition.). Elsevier.

Fadel, D. (2019). Scleral lens issues and complications related to a non-optimal fitting relationship between the lens and ocular surface. *Eye Contact Lens*, *45*(3), 152–163. https://doi.org/10.1097/icl.0000000000000523

Fadel, D., & Kramer, E. (2019). Potential contraindications to scleral lens wear. *Contact Lens and Anterior Eye*, *42*(1), 92–103. https://doi.org/10.1016/j.clae.2018.10.024

Jinabhai, A., Radhakrishnan, H., & O'Donnell, C. (2011). Pellucid corneal marginal degeneration: A review. *Contact Lens and Anterior Eye*, *34*(2), 56–63. https://doi.org/10.1016/j.clae.2010.11.007

Koc, M., Tekin, K., Inanc, M., Kosekahya, P., & Yilmazbas, P. (2018). Crab claw pattern on corneal topography: Pellucid marginal degeneration or inferior keratoconus? *Eye (Lond)*, *32*(1), 11–18. https://doi.org/10.1038/eye.2017.198

Martinez-Abad, A., & Pinero, D. P. (2019). Pellucid marginal degeneration: Detection, discrimination from other corneal ectatic disorders and progression. *Contact Lens and Anterior Eye*, *42*(4), 341–349. https://doi.org/10.1016/j.clae.2018.11.010

Michaud, L., Lipson, M., Kramer, E., & Walker, M. (2019). The official guide to scleral lens terminology. *Contact Lens and Anterior Eye*. https://doi.org/10.1016/j.clae.2019.09.006

Otchere, H., Jones, L. W., & Sorbara, L. (2017). Effect of time on scleral lens settling and change in corneal clearance. *Optometry and Vision Science*, *94*(9), 908–913. https://doi.org/10.1097/opx.0000000000001111

Ozek, D., Kemer, O. E., & Altiaylik, P. (2018). Visual performance of scleral lenses and their impact on quality of life in patients with irregular corneas. *Arquivos Brasileiros de Oftalmologia*, *81*(6), 475–480. https://doi.org/10.5935/0004-2749.20180089

Pullum, K. W., & Buckley, R. J. (1997). A study of 530 patients referred for rigid gas permeable scleral contact lens assessment. *Cornea*, *16*(6), 612–22.

Rathi, V. M., Dumpati, S., Mandathara, P. S., Taneja, M. M., & Sangwan, V. S. (2016). Scleral contact lenses in the management of pellucid marginal degeneration. *Contact Lens and Anterior Eye*, *39*(3), 217–220. https://doi.org/10.1016/j.clae.2015.11.005

van der Worp, E. (2015). *A guide to scleral lens fitting (2 ed.)* (Report). College of Optometry, Pacific University.

Walker, M. K., Bergmanson, J. P., Miller, W. L., Marsack, J. D., & Johnson, L. A. (2016). Complications and fitting challenges associated with scleral contact lenses: A review. *Contact Lens and Anterior Eye*, *39*(2), 88–96. https://doi.org/10.1016/j.clae.2015.08.003

SOPTI Meeting 2020: Abstracts

The 25th National Conference of the Italian Optometric Association (SOPTI) was held in Verona on January 19–20, 2020. The theme of the conference was "Innovative technologies in Optometry and Contact Lenses", was arranged in 3 sessions: optometry, contact lenses, and ophthalmology. Three keynote speakers were invited during the conference: Prof. Rigmor C. Baraas from the University of South-Eastern Norway in Kongsberg, Prof. Silvia Tavazzi from University of Milano Bicocca and Dr. Iwan Zanchetta, clinical practice Rothrist, Switzerland. The abstracts from accepted posters and free papers are presented here.

Received October 15, 2019. Accepted January 4, 2020.

Analysis of sensitivity and specificity of self-report questionnaires on the refractive error

Simone Stefano[1,*] Edoardo Lippolis[1] Silvia Tavazzi[2,3] Fabrizio Zeri[2,3,4] Assunta Di Vizio[5]

[1] Optics and Optometry Degree Course, University of Milano Bicocca, Milan, Italy

[2] Department of Materials Sciences, University of Milano Bicocca, Milan, Italy

[3] Research Centre in Optics and Optometry (COMiB), University of Milano Bicocca, Milan, Italy

[4] School of Life and Health Sciences, Aston University, Birmingham, UK

[5] Department of Optics and Optometry, Roma TRE University, Italy

* Corresponding author: s.stefano@campus.unimib.it

Abstract

Objective and subjective refraction are considered the gold standard for assessing vision defects. Self-reported questionnaires, which are becoming increasingly popular, could be used as an alternative test to detect refractive errors (Breslin et al., 2014; Cumberland et al., 2016; Ip et al., 2007; Walline et al., 1996). The purpose of this study was to assess the accuracy of two self-questionnaires (Q1 and Q2) in identifying refractive errors. In particular, in the Q1 questionnaire interviewees were required to identify their own refractive error choosing among options specified with the scientific term of the condition (e.g. myopia, hyperopia, astigmatism and presbyopia). In the Q2 questionnaire, options available for the interviewees combined the scientific term of the condition with a descriptive explanation of this.

A multicentre study was carried out in six high street optometric practices in Italy. Two hundred and eight participants (mean age 39.7 ± 17.7 years; 65 percent females) were randomly asked to complete one of two questionnaires before an eye examination. The non-cycloplegic subjective refraction of each participant was determined by an examining optometrist in each centre who was masked to the results of the questionnaire. The spherical equivalent refractive error was used to categorise myopia as ≤ -0.25 D, hyperopia as $\geq +1.00$ D, astigmatism ≤ -1.00 D, and presbyopia with a required addition for near greater or equal $+1.00$ D. For each questionnaire the sensitivity and the specificity were determined comparing the self-reported answers with the classification obtained by the subjective refraction.

Questionnaire 1 showed a sensitivity of 0.82, 0.47, 0.72, and 0.58 for myopia, hyperopia, astigmatism, and presbyopia, respectively. In terms of specificity, Questionnaire 1 showed a value of 0.72, 0.75, 0.59, and 0.97 for myopia, hyperopia, astigmatism, and presbyopia, respectively.

Questionnaire 2 showed a sensitivity of 0.90, 0.75, 0.72, and 0.49 for myopia, hyperopia, astigmatism, and presbyopia, respectively. While in terms of specificity, Questionnaire 2 showed a value of 0.80, 0.80, 0.60, and 0.98 for myopia, hyperopia, astigmatism, and presbyopia, respectively. The ROC curves of the two questionnaires are reported in Figure 1.

Both questionnaires used in the study showed reliable results for identifying myopia (see Figure 1). However, their accuracy in allowing hyperopic, astigmatic, and presbyopic participants to correctly identify their condition was poor. Self-reporting questionnaires in Italian language to identify refractive errors are a good option in case of myopia, but not for other refractive errors, for which only objective and / or subjective refraction should be considered.

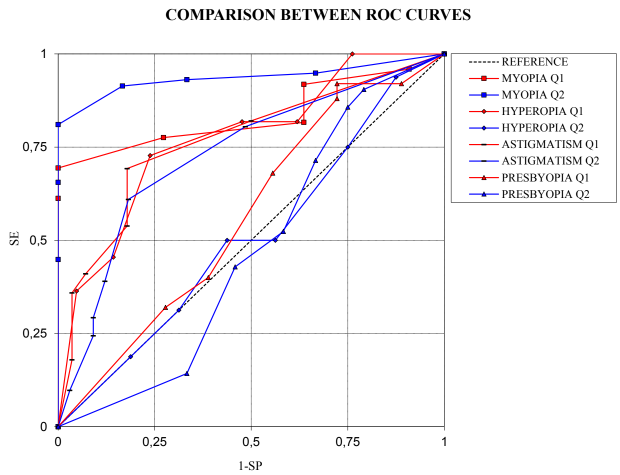

Figure 1.: *The ROC curve for each refractive error calculated for Q1(red line) and Q2 (blue line).*

References

Breslin, K. M., O'Donoghue, L., & Saunders, K. J. (2014). An investigation into the validity of self-reported classification of refractive error. *Ophthalmic and Physiological Optics*, *34*(3), 346–352.

Cumberland, P. M., Chianca, A., & Rahi, J. S. (2016). Accuracy and utility of self-report of refractive error. *JAMA Ophthalmology*, *134*(7), 794–801.

Ip, J., Robaei, D., Rochtchina, E., Rose, K., Smith, W., Wang, J. J., & Mitchell, P. (2007). Can information on the purpose of spectacle use and age at first use predict refractive error type? *Ophthalmic Epidemiology*, *14*(2), 88–92.

Walline, J. J., Zadnik, K., & Mutti, D. O. (1996). Validity of surveys reporting myopia, astigmatism, and presbyopia. *Optometry and Vision Science: official publication of the American Academy of Optometry*, *73*(6), 376–381.

In-vitro Affinity for Nicotine of Contact Lenses of Different Materials

Federica Miglio[1,*] Erika Ponzini[1] Fabio Pezzoli[1] Fabrizio Zeri[1,2,3] Silvia Tavazzi[1,2]

[1] Department of Materials Sciences, University of Milano Bicocca, Milan, Italy

[2] Research Centre in Optics and Optometry (COMiB), University of Milano Bicocca, Milan, Italy

[3] School of Life and Health Sciences, Aston University, Birmingham, UK

* Corresponding author: federica.miglio@unimib.it

Abstract

Nicotine is a toxic compound belonging to the alkaloid family and it is present in high concentrations in the leaves of tobacco plants (*Nicotiana tabacum*). Both smokers and non-smokers are exposed to this chemical because of direct fruition of tobacco derivatives and its presence in the environment as a pollutant (Liu et al., 2018). In clinical contact lens practice, this molecule

can be dangerous because it can adhere to the surface of contact lenses (CLs) (Broich et al., 1980). As for other contaminants, nicotine can have a negative impact on CL properties and ocular health causing infection and inflammation (Panthi & Nichols, 2018; Rabiah et al., 2019). The purpose of this study was to determine the *in-vitro* affinity of CLs to nicotine using UV-VIS spectrophotometry.

Thirteen different materials belonging to 4 out of 5 FDA groups were chosen according to the availability on the market: 1 group I hydrogel CL (Polymacon), 3 group II hydrogel CLs (Nelfilcon A, Omafilcon A, Nesofilcon A), 4 group IV hydrogel CLs (Etafilcon A, Methafilcon A, Filcon IV, Ocufilcon D), and 5 group V silicone hydrogel CLs (Comfilcon A, Delefilcon A, Lotrafilcon A, Lotrafilcon B, Somofilcon A). UV absorbance spectra of each of these CL materials were acquired with a Jasco V-650 spectrophotometer, prior to and after a 10-minute exposure to a 2 mM nicotine solution, followed by a brief rinse in saline solution in order to remove the superficial nicotine. The spectrum of the clean CL was numerically subtracted from the spectra of each CL after the exposure to the nicotine solution. The resulting spectra show a peak centred at about 260 nm, due to the presence of nicotine. The intensity of this peak was then compared to the expected absorbance at the equilibrium (assuming a CL hydration with 0.5 mM nicotine solution), calculated according to the central thickness and percentage of hydration of each CL. The measured/expected ratio provided a relative value which allowed a comparison of nicotine incorporation in the investigated materials.

For each CL, a different measured/expected ratio was found. Group II hydrogel materials showed an absorbance in good agreement with the calculated equilibrium value (range: 0.8-1.0), except for Nesofilcon A, which displayed a ratio of 0.3. On the other hand, Group IV hydrogel materials showed an intensity of the nicotine peak between two and three times higher than the expected equilibrium level (range: 2.1-2.4) and Group V silicone hydrogels showed an opposite result, with a much lower absorbance than expected (0.2-0.4). As far as Group I is concerned, only Polymacon was measured and it showed a ratio of 0.6. In conclusion, despite small differences, similar values were displayed by CLs belonging to the same FDA group: in particular, ionic high-water-content materials (Group IV) presented the highest affinity to nicotine, whereas silicone hydrogels (Group V) showed the lowest. These results suggest that *in-vitro* affinity of CL materials for nicotine depends on their chemical and physical properties.

References

Broich, J. R., Weiss, L., & Rapp, J. (1980). Isolation and identification of biologically active contaminants from soft contact lenses. I. Nicotine deposits on worn lenses. *Investigative Ophthalmology & Visual Science*, *19*(11), 1328–1335.

Liu, S.-H., Tang, W.-T., & Yang, Y.-H. (2018). Adsorption of nicotine in aqueous solution by a defective graphene oxide. *Science of the Total Environment*, *643*, 507–515.

Panthi, S., & Nichols, J. J. (2018). An imaging-based analysis of lipid deposits on contact lens surfaces. *Contact Lens and Anterior Eye*, *41*(4), 342–350.

Rabiah, N. I., Scales, C. W., & Fuller, G. G. (2019). The influence of protein deposition on contact lens tear film stability. *Colloids and Surfaces B: Biointerfaces*, *180*, 229–236.

Inter and intra-observer reliability in tear meniscus height measurement through a new digital acquisition system

Mattia Gerosa[1*] Matteo Fagnola[2] Silvia Tavazzi[1,2] Fabrizio Zeri[1,2,3]

[1] Department of Materials Sciences, University of Milano Bicocca, Milan, Italy

[2] Research Centre in Optics and Optometry (COMiB), University of Milano Bicocca, Milan, Italy

[3] School of Life and Health Sciences, Aston University, Birmingham, UK

* Corresponding author: m.gerosa16@campus.unimib.it

Abstract

The purpose of this study was to evaluate inter and intra-repeatability of the tear meniscus height (TMH) assessment (Wolffsohn et al., 2017) through a new automatic digital acquisition system.

A set of 153 pictures of lower tear meniscus (76 of ODs and 77 of OSs) were selected from the database of the Research Centre in Optics and Optometry (COMiB) and arranged in a new database. Four observers (2 newly graduated optometrists and 2 optometrists with more than 20 years of clinical experience) measured the TMH of each picture in three different points, centrally and at 30 degrees temporally and nasally (Pena-Verdeal et al., 2016; Yokoi et al., 1999), by the new device named *Dry Eye Report* (CSO, Firenze). Each observer was requested to repeat the overall measurement after 15 days. Central TMH results measured by the 4 observers ranged between 0.09 and 0.86 mm and between 0.08 and 0.54 mm on the OD and OS, respectively. Nasal TMH measurements ranged between 0.08 and 0.86 mm and between 0.04 and 0.74 on the OD and OS, respectively. Temporal TMH measurements were between 0.08 and 0.60 and between 0.06 and 0.61 on the OD and OS, respectively. For the OD, the intraclass correlation coefficient (ICC) (Johnson & Murphy, 2005; Koo & Li, 2016) calculated among the 4 observers resulted 0.94, 0.95 and 0.90 for the central, nasal and temporal measures, respectively. For the OS, the ICC resulted 0.94, 0.95 and 0.90 for the central, nasal and temporal measures, respectively. Intra-observer reliability for pictures of both eyes and the 3 positions of measurement was good for all the observers (all ICCs > 0.79).

The inter-observer reliability in assessing TMH by a new digital device of measurement appeared extremely good in terms of ICCs for both eyes and either centrally, nasally or temporally. The intra-observer reliability appeared extremely good, also. More experienced clinicians did not show better ICC values.

References

Johnson, M. E., & Murphy, P. J. (2005). The agreement and repeatability of tear meniscus height measurement methods. *Optometry and Vision Science*, *82*(12), 1030–1037.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163.

Pena-Verdeal, H., Garcia-Resua, C., Barreira, N., Giraldez, M. J., & Yebra-Pimentel, E. (2016). Interobserver variability of an open-source software for tear meniscus height measurement. *Contact Lens and Anterior Eye*, *39*(4), 249–256.

Wolffsohn, J. S., Arita, R., Chalmers, R., Djalilian, A., Dogru, M., Dumbleton, K., Gupta, P. K., Karpecki, P., Lazreg, S., Pult, H., et al. (2017). TFOS DEWS II diagnostic methodology report. *The Ocular Surface*, *15*(3), 539–574.

Yokoi, N., Bron, A., Tiffany, J., Brown, N., Hsuan, J., & Fowler, C. (1999). Reflective meniscometry: A non-invasive method to measure tear meniscus curvature. *British Jjournal of Ophthalmology*, *83*(1), 92–97.

Corneal topography in assessing Extended Depth of Focus CL centration

Giulia Carlotta Rizzo[1,*] Assunta Di Vizio[2] Silvia Tavazzi[1,3] Fabrizio Zeri[1,3,4]

[1] Department of Materials Sciences, University of Milano Bicocca, Milan, Italy

[2] Department of Optics and Optometry, Roma TRE University, Italy

[3] Research Centre in Optics and Optometry (COMiB), University of Milano Bicocca, Milan, Italy

[4] School of Life and Health Sciences, Aston University, Birmingham, UK

* Corresponding author: g.rizzo21@campus.unimib.it

Abstract

The study was carried out to evaluate accuracy and inter- and intra-observer reliability of the centration assessment of an extended depth of focus (EDOF) soft contact lens (CL) developed by Brian Holden Vision Institute for myopia control, by corneal topography.

Thirty-three myopic volunteers (25 females) age range 18.6–27.9 years (mean ± *SD*; 22.7 ± 2.0 years) were recruited among the students of Milano-Bicocca University (Milan, Italy). All measurements were performed at the Research Centre in Optics and Optometry (COMiB) of the same university. EDOF CLs (Mylo, Mark'ennovy, Spain) were fitted in both eyes of each participant except for two of them because only one eye met all inclusion criteria. For any EDOF CL, a videokeratography over the CL (Osiris-T, CSO, Italy) and a slit lamp (SL) digital picture (HR-Elite, CSO, Italy) were taken in a randomised sequence. For the SL images, the Phoenix software was used to assess the position (coordinates x and y) of the EDOF CL centre respect to the centre of the pupil in a Cartesian plane. For the videokeratoscophic acquisitions, the position of the EDOF CL centre in respect to the centre of the pupil was detected using a qualitative procedure directly from the topographic map (tangential algorithm), by two different observers (one newly graduated optometrist and one optometrist with more than 20 years of clinical experience) and repeated twice in two different sessions with a 15 days delay.

Accuracy of the topographic assessment in determining coordinates of the EDOF CL centre with respect to SL assessment was good. No significant difference was found in the left eyes, whereas in the right eyes a less temporally decentred position of the CLs was detected (paired t-test, $p < 0.05$). Nevertheless, this difference appeared clinically negligible (0.14 ± 0.22 mm). The difference between the 2 observers in assessing CLs centration by topographic map was not significant for horizontal coordinates of both eyes, but a significant difference was found for vertical axes (paired t-test, $p < 0.05$). The intra-class correlation coefficient (ICC) was calculated for each coordinate (x, y) and for each eye amongst the two measures achieved in CL centration assessment by the topographic procedure by each observer. ICCs were very good (between 0.64 and 0.88) in each observer, except for the horizontal decentration value relative to the right eye, which for the observer with less experience dropped to 0.58.

In conclusion, assessing CL centration by performing topography over an EDOF soft CL appeared to be an accurate method. Intra and inter-observer reliability of the measurement were good.

A feasible way to quantitatively measure the sensory eye dominance

Nicola Megna[*] Francesca Natalini, Giampaolo Lucarini, Alessandro Fossetti

Institute of Research and Studies in Optics and Optometry, Vinci, Italy

Corresponding author: nicolamegna@gmail.com

Abstract

This study investigates the possibility of developing a sensory eye dominance test on a continuous scale, based on performance rather than on the subject's introspective response. Determining sensory eye dominance (SED) is important in some optometric interventions influenced by the integration of information coming from the two eyes (Evans, 2007). Several studies have found inconsistencies between traditional dominance measurements (Mapp et al., 2003; Walls, 1951). SED seems to vary according to the type of test and its conditions, such as the distance and the eccentricity of the stimulus (Khan & Crawford, 2001). These inconsistencies may result from tests that are dichotomous and based on the patient's subjective impressions. Some scientific research uses SED tests based on ocular balance indexes, currently not used in the clinical context due mainly to the required administration times (Bossi et al., 2018).

Thirteen observers participated in the experiment. Stimuli presentation and data analysis were performed using Psychopy and other scientific Python modules (Peirce & MacAskill, 2018). A dichoptic stimulus previously used by Reynaud & Hess (Reynaud & Hess, 2017) in order to produce a Pulfrich effect (Pulfrich, 1922) that allows the illusory three-dimensional perception of a cylinder that rotates clockwise or counterclockwise, was modulated in terms of ocular disparity and contrast. The stimuli were fused through two prismatic lenses mounted on a stereoscope prototype built in our laboratory. The observers were asked to report the perceived direction of rotation. In this way, psychometric curves were obtained for the proportion of clockwise responses related to ocular disparity and contrast difference between the two stimuli. Furthermore, three traditional dominance tests were conducted on each subject: the red filter, positive lens (sensory) and pointing (motor) test.

Firstly, we assessed the repeatability of our test on three subjects from our sample who carried out the measurements two times with one week between measurements, showing similar results within their trials. From the psychometric curves, we estimated the balance point between eyes in terms of the ocular disparity which produced an inversion of perceived rotation. We found that it was significantly different between observers whose results were consistently right ($N = 4$), left ($N = 4$) or ambiguous dominant for the combination of traditional tests [$F(2,10) = 6.196$, $p = 0.017$], and estimated that the information from the dominant eye could be processed on average 8.2 ± 5.8 ms faster than that of the other eye. Observers with a dominant left eye showed more marked differences in processing times (6.8 ± 2.0 ms) than people with a dominant right eye (1.5 ± 0.9 ms). The subjects that do not show a clear dominance had no differences in processing times between the eyes (1.2 ± 1.7 ms). These results are consistent with the literature (Read & Cumming, 2005) and underline the need to distinguish the peripheral from the hemispherical SED (Jasper & Raney, 1937; Rombouts et al., 1996). We are currently resolving this critical issue in order to develop a new SED quantitative test for use in clinical practice.

References

Bossi, M., Hamm, L. M., Dahlmann-Noor, A., & Dakin, S. C. (2018). A comparison of tests for quantifying sensory eye dominance. *Vision Research*, *153*, 60–69.

Evans, B. J. (2007). Monovision: A review. *Ophthalmic and Physiological Optics*, *27*(5), 417–439.

Jasper, H. H., & Raney, E. T. (1937). The phi test of lateral dominance. *The American Journal of Psychology*, *49*(3), 450–457.

Khan, A. Z., & Crawford, J. D. (2001). Ocular dominance reverses as a function of horizontal gaze angle. *Vision Research*, *41*(14), 1743–1748.

Mapp, A. P., Ono, H., & Barbeito, R. (2003). What does the dominant eye dominate? a brief and somewhat contentious review. *Perception & Psychophysics*, *65*(2), 310–317.

Peirce, J., & MacAskill, M. (2018). *Building experiments in psychopy*. Sage.

Pulfrich, C. (1922). Stereoscopia al servizio della fotometria isocromica ed eterocromica (Springer, Ed.). *Scienze Naturali*, *10*(35), 751–761.

Read, J. C., & Cumming, B. G. (2005). Effect of interocular delay on disparity-selective v1 neurons: Relationship to stereoacuity and the pulfrich effect. *Journal of Neurophysiology*, *94*(2), 1541–1553.

Reynaud, A., & Hess, R. F. (2017). Interocular contrast difference drives illusory 3d percept. *Scientific Reports*, *7*(1), 1–6.

Rombouts, S. A., Barkhof, F., Sprenger, M., Valk, J., & Scheltens, P. (1996). The functional basis of ocular dominance: Functional mri (fmri) findings. *Neuroscience Letters*, *221*(1), 1–4.

Walls, G. L. (1951). A theory of ocular dominance. *AMA Archives of Ophthalmology*, *45*(4), 387–412.

Italian optometry in an European framework, between history and function

Anto Rossetti

Degree Course in Optics and Optometry, Department of Physics, School of Sciences, University of Padua, Italy. Optics Section, State Institute Paolino d'Aquileia, Cividale del Friuli, Italy

Corresponding author: anto.rossetti@unipd.it

Abstract

Ophthalmic optics and optometry together are a unitary field, both historically and functionally. Even now, European associations (European Council of Optometry and Optics ECOO and European Academy of Optometry and Optics EAOO) represent both professions. Nevertheless, there are differences in functions, but the common ground of optical aids for vision function remain. *Ante litteram* opticians started to prepare eyeglasses in the XIII century in Italy. The year 1286 is used as a symbolic date for the first eyeglasses (Ilardi, 2007) even if the real date is probably earlier (Cappa, 2004). There is evidence that eyeglasses for myopia were specifically selected, sold and used already in the XV century in Italy (Ilardi, 2007). So, the specific practice of optics spans over 7 centuries. In Italy, one traditional "optician" dates back to 1856 and is still active in the same place, and another one which is still active dates back to 1802 (Raffaele Sacco). These are both in Naples. It must be highlighted that eyeglasses, even during the XIX century, found opposition by medical professionals. Antonio Scarpa (1826), an Italian eye surgeon famous in Europe, wrote a short textbook to promote visual hygiene, and against "lasciviousness" in order to prevent myopia. The same book warns about the use of concave eyeglasses, but considers convex lenses "less harmful". This radically different approach – opposing opticians and oculists – shines light on different styles of thought at the time: for physicians the goal was to remove eye defect (i.e. to cure); instead, for opticians the goal was to correct and re-establish visual function. Looking back from actuality, both approaches seem incomplete: use of corrective lenses without evaluating causes or applying a treatment without real knowledge of causes. The "opticians' approach" has shown efficacy, and refractive correction with lenses remains the preferred and scientifically based option. The "cure" of refractive errors is still is being studied. Activity of opticians as a regulated profession can be traced far back in local guilds, like the one of *Christalleri* in Venice, in the XIII century (De Lotto, 1956). In 1928 a law was introduced which regulates the practice of opticians in the unified Italy. This law still applies and gives opticians the license to refract for "simple defects of myopia and presbyopia". This poses the role of opticians under Category 2 of WCO, not to be confused with the "dispensing optician" of English-speaking countries. In 1969-70 advanced education in optometry started, for licensed opticians only, both in Milan and Vinci/Florence (the latter Institute is still active as IRSOO). Many educational projects on optometry followed, none fully establish a standard. In 2001 a three-year university program in "optics and optometry" was started (as a specific Physics degree, within the Science School) in Milan and rapidly other universities followed. In 2018, Italian optics and optometry associations developed a two-level registration, for *optician* and *optometrist-optician*, based on the different education, competencies and qualifications of the two (Registro TiOpto). Most of the current practices in Italy are independent. Generally speaking, all optometrists are also licensed as opticians, but not all opticians are qualified as optometrists, respectively in a ratio of about 4:1 (opticians to optometrists).

References

Cappa, S. (2004). *Conspicilla: Storia comparata di sette secoli della professione oftalmica*. Grafiche G7.

De Lotto, E. (1956). *Dallo smeraldo di nerone agli occhiali del cadore*. Tiziano.

Ilardi, V. (2007). *Renaissance vision from spectacles to telescopes* (Vol. 259). American Philosophical Society.

Contact lens use, what to do to get a severe microbial keratitis

Pasquale Cirillo[1,*], Mauro Frisani[2], Marina Serio[2]

[1] ASL Naples 1

[2] Department of Optics and Optometry, University of Torino, Italy

* Corresponding author: cirillopasquale@gmail.com

Abstract

Inappropriate use of contact lenses is the most common cause of severe ocular microbial keratitis. Severe microbial keratitis can reduce visual function. In Italy there have been no studies into the incidence of microbial keratitis in contact lens wear. The purpose of this study was to investigate habits of contact lens wearers in relation to severe microbial keratitis and describe associated risk factors.

A total of 49 subjects with severe microbial keratitis responded to a survey between November 2018 and May 2019. All subjects were in ophthalmological hospital for pharmacological treatment after diagnosis of severe microbial keratitis associated with contact lens use, and all were disposable soft contact lens wearers. The survey was retested on 22 subjects one month after the first test. The participants were aged from 16 to 67 years (mean 37 years), 74% were female. No rubbing of the lens after use was reported for 98% of the sample. 83% reported that they had not visited an eye specialist to have contact lenses fitted. Water exposure (tap water, swimming pool, shower) was reported for 72% of the sample. 55% reported waiting longer than 1 month before replacing the contact lens case. 49% slept with contact lens in the eyes almost 1 or 2 night a week. 49% reported waiting longer than the recommended time before changing their contact lenses.

Risk factors associated with severe microbial keratitis were reported. It is necessary to educate contact lens wearers to establish safe habits.

Corneal densitometry changes after orthokeratology treatment

Mauro Frisani*, Valeria Morano, Michela Greco

Department of Optics and Optometry, University of Torino, Italy

Corresponding author: mauro.frisani@unimib.it

Abstract

Densitometry is a measure of transmission of light. Orthokeratology is an effective treatment for myopia control. It has been established that it is a reversible modelling of corneal epithelium. Actually, there is no study of corneal densitometry after orthokeratology treatment over short and long period. The aim of this study is to analyse the densitometry of the sublayers of human corneas that have undergone orthokeratology treatment for two years.

Scheimpflug images of 70 eyes of 36 subjects, aged from 9 to 15 years, that underwent orthokeratology treatment for myopia control have been collected for this retrospective study, before and after two years of orthokeratology. The images have been processed through MATLAB scripts. The central vertex and the external edge of the cornea were identified and the optical density for each sublayer within the 3 central mm was measured. The data thus obtained have been analysed with the Shapiro Wilk and *T*-test (Wilcoxon signed-rank test), in order to assess the statistical significance. The values related to the right eyes of the sample have been analysed. The densitometric values in GSU (Grey Scale Unit) before the orthokeratology treatment and after two years of continuous wear highlighted a difference from 18.1 ± 1.04 to 18.7 ± 1,4 (Mdn = 18.0, CI 95%, W = 81, p = 0.02) for the epithelium-Bowman complex, from 10.7 ± 0.8 to 11.2 ± 0.8 (CI 95%, t = 3.63, M = -0.51, p = 0.00) for the stroma, and from 5.1 ± 0.6 to 5.0 ± 0.7 (CI 95%, t = 0.92, M = 0.12, p = 0.37) for the endothelium.

The difference in densitometric values for the primary corneal layers of normal subjects, measured before and after two years of orthokeratology treatment, turned out to be statistically significant for the epithelium and the stroma. However, these differences are not considered clinically significant, as the measured variations of refractive index are minimal. Currently, the minimal normal values of the density variation occurring physiologically or by wearing other kinds of contact lenses cannot be determined because of the characteristics of the assessed sample.

Corneal densitometry differences between two Scheimpflug camera

Mauro Frisani[1*] Alice Dibenedetto[1] Michela Greco[1] Ugo De Sanctis[2]

[1] Department of Optics and Optometry, University of Torino, Italy

[2] Eye Clinic, Surgical Sciences Department, University of Turin, Italy

* Corresponding author: mauro.frisani@unimib.it

Abstract

Densitometry is a measure of transmission of light. Measurements of corneal densitometry are useful to observe effects of contact lenses, ocular treatments, or surgical intervention. The Scheimpflug camera is a principle of photography, which when applied with a specific device can visualize and make further analysis on the anterior segment of the eye. The purpose of this study was to compare measurements of corneal densitometry taken with two commercially available Scheimpflug camera devices.

A total of 66 images of 24 normal eyes of 12 subjects were analysed with Sirius (CSO, Italy) and Pentacam (Oculus, Germany). Subjects were aged from 20 to 22 years, 64% were female. GSU (Grey Scale Unit) index for principal corneal sublayers were extrapolated. GSU from Pentacam images were extrapolated using proprietary software, GSU from Sirius images were extrapolated by a bespoke algorithm based on Matlab. For the anterior sublayers of the cornea (120 μm for Pentacam, Epithelium-Bowman for Sirius) a statistically significant difference was found between the two devices ($p < 0.001$ Wilcoxon signed-rank test; mean and standard deviations values of 16.80 ± 0.66 GSU for Pentacam and 17.55 ± 0.70 GSU for Sirius; 95% range of difference from 0.76 to 1.07). A statistically significant difference was also found between the two devices for the posterior sublayers of the cornea (over 120 μm for Pentacam, stroma for Sirius) ($p = 0.02$ Wilcoxon signed-rank test; mean and standard deviations values of 10.50 ± 0.48 GSU for Pentacam and 10.62 ± 0.56 GSU for Sirius; 95% range of difference from 0.01 to 0.21)

GSU values for each device were reported for the principal sublayers of the cornea. Statistical differences for each sublayer were found, but our data suggests a difference of 1 GSU unit as maximum difference. It is not possible to consider the clinical significance of these differences due to a lack of normal values reported in scientific literature for the two instruments.

Is it possible to predict the ocular aberrometry variations with bitoric soft contact lenses in irregular astigmatism?

Virginia Rovea*, Mauro Frisani, Michela Greco

Department of Optics and Optometry, University of Torino, Italy

Corresponding author: virginia.rovea@gmail.com

Abstract

Corneal surface irregularity can introduce high order aberrations often not correctable with spectacles. New generation soft contact lenses with bitoric design may be useful in correcting higher-order aberrations. The bitoric design is characterized by both the anterior and posterior surfaces being toric, and their principal advantages is almost normal thickness. The disadvantage is that more chair-time is required for trialling the lenses and calculating the final parameters compared with other lenses. A better predictability of objective effectiveness would be useful in cutting down on time consuming procedures.

The purpose of this study was to analyse the effects on coma and astigmatism aberrations of bitoric soft contact lenses in subjects with irregular astigmatism and to assess the measurement differences of aberrations by using an aberrometer and a topographer.

A retrospective study was performed on a selection of 22 subjects with irregular astigmatism divided into 14 right eyes and 15 left eyes for a total of 29 examined eyes. Each eye had BCVA with spectacles lower (better) than 0.3 logMAR. Each eye was fitted with soft bitoric contact lens (TDK, TSlac, Italy). Aberrations index, from Osiris (CSO, Italy), for astigmatism, coma, and spherical aberration, for a pupil diameter of 4 mm, were extrapolated with and without the contact lens fitted. Indexes were compared with ANOVA to evaluate the effect of the contact lens on aberrations.

In the comparison between before and after contact lens application the statistical analysis did not reveal any significant difference in predictability of changes in aberrations, although the means of single aberrations showed a decrease of vertical

coma in both samples (right eyes and left eyes).

The study does not show any predictability of objective efficacy, compared to high order aberrations, of bitoric soft contact lenses in subjects with irregular astigmatism. Evaluation of efficacy with trial lenses and comparison with subjective variations are necessary to assess the efficacy of bitoric contact lens fitting in general irregular astigmatism.

Imaging cone-to-RPE connections in the living human retina

Rigmor C. Baraas[1*] Hilde R. Pedersen[1] Stuart J. Gilson[1] Kenneth Knoblauch[1,2]

[1] National Centre for Optics, Vision and Eye Care, Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

[2] Inserm, Stem Cell and Brain Research Institute U1208, Université Claude Bernard, Lyon, Bron, France

* Corresponding author: Rigmor.Baraas@usn.no

Abstract

Multimodal adaptive optics scanning light ophthalmoscopy (m-AOSLO) allows for high resolution in-vivo imaging of the human retina. The m-AOSLO instrument in Kongsberg currently allows for the following modes of imaging: in-vivo reflectance confocal, split-detector and dark-field imaging (Pedersen et al., 2020; Scoles et al., 2013; Scoles et al., 2014). Thus, resolving individual photoreceptor cells (1–2 μm in size) and individual retinal pigment epithelial cells. It is non-invasive and allows monitoring in the authentic anatomical setting of the living human eye. The retinal pigment epithelium (RPE) is essential for appropriate development of the human retina, through promoting photoreceptor development and differentiation. RPE cell maturation is thought to play a critical role in defining foveal specialization and shape. Results from an ongoing study on the relationship between foveal shape obtained from OCT imaging and cone and RPE cell density profiles of healthy adults will be presented and discussed.

References

Pedersen, H. R., Baraas, R. C., Landsend, E. C., Utheim, Ø. A., Utheim, T. P., Gilson, S. J., & Neitz, M. (2020). PAX6 genotypic and retinal phenotypic characterization in congenital aniridia. *Investigative Ophthalmology & Visual Science*, *61*(5), 14–14.

Scoles, D., Sulai, Y. N., & Dubra, A. (2013). In vivo dark-field imaging of the retinal pigment epithelium cell mosaic. *Biomedical Optics Express*, *4*(9), 1710–1723.

Scoles, D., Sulai, Y. N., Langlo, C. S., Fishman, G. A., Curcio, C. A., Carroll, J., & Dubra, A. (2014). In vivo imaging of human cone photoreceptor inner segments. *Investigative Ophthalmology & Visual Science*, *55*(7), 4244–4251.