A journey of innovation or rediscovery?

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Abstract

Good research should be an integral part of the continued development of the discipline of orthoptics and yet many practitioners do not consider research fundamental to their practice. Research is often seen as the domain of the universities and whilst it is a major part of the university role research is increasing in importance in clinical practice with the current shift to evidence based practice. The subject of this paper is to discuss the concept of research in an attempt to encourage all practitioners to consider research a part of their daily practice. An overview of the development of the scientific method is presented including the contribution of observation and trial and error. The more formal elements of literature search, research design and statistics are considered in the clinical context.

I wish to thank Council for the honour of asking me to present the 1999 P M Lance Lecture. Patricia (Pat) Lance MBE is a great pioneer of orthoptics. I am grateful I joined the Orthoptic profession at a time when pioneers such as Pat Lance; Bev Balfour and Diana Craig were still active in the profession, my regret is not joining early enough to actively work with such people. Each of these early pioneers was in the true sense a researcher. These pioneers established the discipline of orthoptics as a science based on research. We must continue with these principles today if we want our discipline to grow and have standing with other professional areas.

As defined in the Oxford Dictionary research is a "careful search or inquiry; endeavour to discover new facts etc. by scientific study of a subject; course of critical investigation". It is in the broadest sense that I wish to define research, that is, an exploration of new ideas leading to the development of theory and practice. However, research is often seen as a complicated scientific process that takes place in universities and requires specific training. Whilst to some extent this is true, research is also an activity in which we can all be involved in. This lecture will be used to present the concept of research as a journey of discovery, an activity to be enjoyed not feared. Aspects of my own research will be referred to as illustration of certain points on the journey.

Research: the concept.

The early scientists were very much philosophers who created theories to explain the phenomena around them. An interesting example of the changes in approach to research can be seen in the development of the periodic table of elements, which is fundamental to our understanding of chemistry and the world around us.

Key concept: A large step forward in knowledge is often based on many small steps and therefore scientific theory can be slow to develop.

- Empedocles (c490 to 430 BC) theorised that everything on Earth was made not from one substance as was the view of his predecessor's but was instead derived from 4 elements - fire, wind, water and earth.
- Aristotle (c384 - 322BC) took Empedocles theory further by seeking to classify Empedocles four elements into subgroups thus introducing a greater level of organization into our view of the world. This theory of organization remained the cornerstone of chemical science for 2000 years.
- John Dalton (1766 - 1844) introduced the concept of all matter being composed of atoms, that atoms had a specific weight and that when elements combined to form compounds they did so in specific proportions.
- Dmitry Mendeleyev (1834 - 1907) took this information a step further determining that there was an inter-relationship amongst chemical elements based on their atomic weights this classification formed the periodic table as we know it.

Development of the scientific method.

Key concept: The use of research to support theory remains basic to science to this day.

Aristotle's lasting contribution to science was his insistence on observation and classification and initiating research to facilitate this process.

Key concept: It is as important in scientific research to record failure as well as success, we can learn much from analysing failure.

Hippocrates (c460 - 377 BC) the "father" of modern medicine established experience and observation as the basis of medical diagnosis. Whilst Hippocrates is perhaps better remembered for The Hippocratic Oath he left another great legacy to science and that was his insistence on recording failures as well as successes.

Galileo (1564 - 1642) Wrote the first paper describing scientific method in the 1620's. Today the scientific method has been claimed by many disciplines from Psychology to Geography. In recent times the traditional scientific method as the basis of

research has given way to two areas of methodology: quantitative and qualitative research. Quantitative research results in outcomes, which can be measured in numeric terms and analysed by statistical calculation. Qualitative methodology enables us to explore phenomena that do not lend themselves to quantitative measurement such as human feelings or the impact of disability on quality of life. Research in the health sciences requires both methodologies and often both may be employed to answer the one research question.

Research: the process

In my opinion a good glass of red wine and a decent bowl of pasta are an integral part of the research process! As enjoyable as the pasta and wine may be they are really only an allegory for time to think. If one becomes totally involved in research it becomes a lifestyle not just an occupation! The research process requires a flow of ideas which is not achieved by waking up one morning and saying "today I will do research!" Ideas will have been generated by your observations and experiences, they may not be immediately useful, but remain stored in memory until the right sequence of events occurs.

Key concept: Simple observation can be a powerful tool.

Hans Lippershey (c 1570 - 1619) a German born spectacle maker who lived and worked in the Netherlands is credited with discovering the telescope. Allegedly a child playing in his shop put two lenses together and noticed that distance objects came closer, from this observation Lippershey developed the telescope (Not verified).

Key concept: Good research should be based on careful observation and thorough evaluation.

Observation alone does not result in good research. Observations are often matched against existing theory to develop new concepts, which must then be tested. Some examples based on my own experience where observation has lead to the development of new clinical tools can be seen in the development of both the EccVue and the VizTest computer programs.

- The idea to develop EccVue grew from a number of sources from my personal experiences with clients learning the process of eccentric viewing. I was frustrated by my inability to create good quality training materials, by the limited range of materials available and the lack of a simple and repeatable training method. Combining these frustration's with some basic educational theory and the versatility of the desk top computer resulted in the development of EccVue1.
- VizTest germinated from my clinical work assessing multiple-handicapped children. I found that existing tests were not suited to the abilities of the children being tested. However, the alternative to substitute conventional test procedures with batteries of toys and pictures was cumbersome and ineffective as a means of measurement. In this case my observation of the problems encounted by the children in trying to respond to conventional clinical tests and the use of procedures which could not provide meaningful assessment lead to a complete change in my approach to thinking about the problem. The new approach was to establish images that would be meaningful and of interest but still provide a degree of clinical measure combined with a method of response suited to the children. These ideas were then evaluated with the target children and validated against conventional tests 2 3 4.

The result has been two new successful and novel clinical procedures.

Key concept: Not all research is based on an "original" idea sometimes it is the development or novel application of an existing concept.

Some aspects of research are also serendipidous. In my case the move into using computer technology came from a combination of my own interest, sporadic exploration of computing and the chance meeting with a colleague who was skilled in computer programming. The idea of using computers as a means of providing vision rehabilitation programs and a means of assessing functional vision was an extension of my desire to create better materials and a basic knowledge which indicated the computer would be the appropriate vehicle to achieve this. By chance finding a colleague who had appropriate computer skills and a desire to further explore the application of computer technology enabled us to convert my ideas into working programs.

Research is not only the creation of new ideas and concepts but is often the result of old ideas being placed into a new context. The development of computer technology is a good example of looking at old ideas in a new light and in this case ideas which were probably much older than most people realise! The development of computer technology is a good example of concept development in research.

The first computer was actually designed by Charles Babbage (1792 - 1871) who also invented an early ophthalmoscope. Babbage's computer was an extension of the calculators of the day, which in turn had their roots in the abacus. Babbage observed the pattern cards which had been developed by Joseph Jacquard to control the complex patterns created by weaving looms and believed the same technology could be used to feed instructions into a calculator to enable it to perform more complex calculations. Babbage reasoned he could use these "batch cards" to control an "analytical machine". The machine would be controlled by programmed instructions and have a memory to allow comparison with previous data, thus the digital computer was born, although not activated until much later.

It was not until the 1930's that Babbage's design was put into practice when differential analysers powered by electricity were developed and the analogue computer was born. As with many forms of technology computers were further advanced during wartime as decoders. The following is a brief chronology of computer development in more recent times that illustrates the evolution of an existing concept.

- Britain developed the Colossus which filled a room and could read coded tape at tremendous speed.
- The Americans had independently developed the Electronic Numeric Integrator and Computer (ENIAC) to calculate gun trajectories. This machine also occupied a whole room it weighed in excess of 30 ton and generated so much heat it could not run for more than an hour at a time. It used so much power that all the lights in the surrounding district dimmed when it was turned on If a valve broke down it could take up to 8 hours to locate the problem! This was the first digital computer, which operated on a binary system.
- Australia was also a part of this computer revolution. Council for Scientific and Industrial Research Automatic Computer (CSIRAC) was developed by the Council for Scientific and Industrial Research. Development began in Sydney in the late 1940's moving to Melbourne in the 1950's. This large machine looked like a series of gym lockers it had 2 kilobytes of memory and an output of 4 characters a second. For those who think their Personal Computer's are pretty clever when they play Compact Disc's, CSIRAC also played music through rather primitive speakers. CSIRAC was used to run calculations on building design and the State's electricity distribution system.
- 1951 saw the first commercially available computer the Ferranti mark 1, which was developed in Manchester England.
- 1960 the development of integrated circuits revolutionised computer development so that by 1977 Robert Noyce wrote in Scientific American: "Today's micro computer at $300 has more capacity than ENIAC, it is 20 times faster, has a larger memory, is a thousand times more reliable, consumes the power of a light globe not a locomotive, occupies 1/30,000 the volume, costs 1/10,000 of the cost and is available by mail order from your local hobby shop!"

Computers were mainly used for their ability to perform complex calculations and their phenomenal memory storage capacity. Even in the mid 1980's when my colleague and I were formulating our ideas computers were rarely being used in therapy. Yet the computer offered the ability to store many images and manipulate those images with ease and speed. In addition computers were interesting; - an observation I had made in the Special Development Schools where I was working.

Research: where do you find it?

Key concept: Search widely, if you have had a good idea someone may have had it before you.

Another intrinsic component of research is the literature review - so, you have an idea, has some one else had the same idea? Perhaps some one else done work that might add to or help define your idea. My literature searching on eccentric viewing took me back to the 1970's when the idea of vision rehabilitation was sweeping America.

This searching demonstrated early attempts at eccentric viewing and demonstrated a number of paradigms based on bright lights5. As an orthoptist this literature should have suggested an obvious training method, pleoptics. My clients with centre field loss are extremely photophobic, the use of an afterimage would be extremely distressing to them and I initially dismissed this suggestion. However further thought about the basic concepts of pleoptics (without the bright lights) did lead to the development of the eccentric stimulation component of the EccVue package (Figure 1). This component has proven to be a useful feature of the package. It enables the clinician to check if the eccentric viewing position selected on the basis of vision field testing is appropriate; and it gives the client a good idea of the quality of vision to be expected from the eccentric viewing point. The ideas I found in the earlier literature proved to be quite successful when applied in a modified form

Literature searching for VizTest took me even further back to the 1870's and the first attempts to develop accurate tests of vision. Key factors in the early development of vision charts related to optotype legibility. A point of interest in this literature relates to the initial choice of optotypes, which was based on convention not science. Snellen's first optotypes were in a font known as Egyptian Paragon a print type with serif. Green suggested that a print type without serif would form a better optotype his idea was dismissed on the basis that it would not be pleasing to the eye!6 So much for scientific method. My literature searching enabled me to better understand the process of vision chart development as well as detecting the lack of tests devised specifically for the population in which I was interested.

Key concept: Many good developments are the result of taking a "different" approach to an existing idea.

After my literature searching in relation to development of tests of visual acuity I was left with the question: what did all of these conventional and modified conventional tests have in common and why were they not suited to my population of interest?

- The tests were developed in high contrast so always black on white;
- Where pictures were employed they were stylised pictograms, which require a high degree of cognition and familiarity for recognition.
- The only tests suggested for less cognitively developed subjects consisted of black and white gratings. Such targets are boring for the target population.
- Finally there was a big jump in testing procedures from the strictly controlled clinical tests to the inventory style questionnaires being developed by allied health professionals working in the field who had no training in vision assessment.

Not all research fits comfortably within conventional thinking sometimes the researcher has to be prepared to go out on a limb; this was the case with VizTest. Having studied the work of my colleagues and considered the short comings of existing designs I decided the basis of the problem was taking a validated test and trying to modify this to suit the

population. Why not start from the known abilities of the population and then find a way of gaining meaningful information Figure 2 demonstrates the basis of optotype design for VizTest, a very unconventional optotype!

Research: doing it!

Key concept: Clinical research may not always be as exacting as controlled laboratory research but it does not have to be without rigour or validity.

Having made your observations, formulated your theories and considered the current thinking comes to the fun part of designing the "experiment" and collecting the data. I am not going to speak at length on the theory of experimental design but rather raise a few points for consideration.

Knowing in our heart of hearts that a particular intervention works because we have observed our patients improve in the clinic and had that warm fuzzy feeling when the client/patient walks away delighted does not prove the validity of your method. To convince the hardened critics a good random controlled study with plenty of statistical power is best practice. This it is not always practical or achievable in the work place but that is not an excuse to ignore good research principles, some methodologies are simple but effective.

If you are unable to establish a full random controlled study some degree of validity can be gained from a pre / post test design to demonstrate a change in behaviour or performance. This design enables measurement of change and provides the basis for statistical analysis. When I designed EccVue I was not able to gain access to a sufficiently large number of clients to make a random controlled experimental design viable. There was also the ethical dilemma that confronts all clinical researchers - should I withhold treatment? To overcome these problems I used a pre/post test design to evaluate EccVue7. Objective pre training measures combined with a subjective functional evaluation were used to test my hypothesis that EccVue was an effective method of training eccentric viewing. Post training I re-tested the objective measures (Figure 3) and asked clients to complete an evaluation questionnaire relating to perceived functional changes. In this design the traditional subject and control groups are replaced by developing base-line data and then providing comparative measures. This is valid research but the researcher must be aware of the limitations of the conclusions. For example improved performance may be due to the attention received and not the intervention the "Hawthorne effect".

The research design involved in assessing VizTest was undertaken in the university environment and was more rigorous. This was not just a new test but it incorporated new designs in optotypes. The new optotypes had to be validated by comparison with an existing "gold standard" test. This testing was undertaken with 96 cognitively normal children with varying levels of visual acuity, testing was undertaken with two examiners each blind to the results of the other - to minimise bias. The new test then had to be evaluated with a sample population similar to our target population. Subjects were chosen on the basis of their (or parents) agreement to participate - this does not eliminate all bias but when working with clinical populations this is often the closest one comes to random sampling. Secondly we needed to have a good-sized sample we achieved this by sampling from a number of centres. This added to the statistical power and the confidence with which we could extrapolate our results to the target population as a whole.

Validation testing allowed the calculation of sensitivity and specificity data for the test as a whole and for individual optotypes (Table 1). The optotypes were also evaluated for legibility so that the final selection of picture optotypes would be of comparable legibility. Evaluation trials indicated the applicability of the test to the target population and tested the concepts of coloured optotypes and movement as components of a vision test4.

I have presented two examples of methodology, one limited by the clinical practice environment the other set in an academic context. There are times when a project seems never ending - a long uphill climb, it is still worth doing well.

Key concept: A researcher must find time to reflect on the data and methodology.

Time to reflect - back to the wine and pasta! An important part of the research process is time to think and reflect on your work. A good scientific study does not spring up overnight (even though it may appear to). The time spent in formulating the ideas for EccVue and trying to gain grant money to support development probably appeared to my colleagues to have occurred with little obvious time input. The reality was much of this work was done through the night and on the weekends. This is not a satisfactory way to approach research particularly in the long term, appropriate time must be found. How do you find time? I learned this the hard way and not without a large amount of soul searching, this will require making sacrifices. So what should they be?

- Give up your partner? - probably not;
- Give up sleep? - not long term;
- Rationalise the workload? Yes!

If you are going to undertake a research project do it properly and factor this into your workload which means something else will have to come out. This is never an easy decision but if you are to be productive and not have a nervous breakdown it is essential.

I have talked about the research journey in terms of observation and awareness of other work in the field. The ability to adapt existing knowledge and be bold enough to break with convention and imagine new ideas. I have touched on the need for careful planning and good design to support and validate our work. I hope I have encouraged you to consider taking on this process because we all should contribute. There remains but one point to be made:

Most of all research should be FUN- thank you.

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