"Brain training": Two Types of Approaches to Intervention, and Two Approaches to Evaluation

Il "Brain Training": due diversi approcci all'intervento e alla valutazione

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ABSTRACT

This paper explores a 2016 paper published by Simons and colleagues on the efficacy of 'brain training' programs, in relation to the Feuerstein Instrumental Enrichment program for teaching thinking. It compares the focus of this Simons paper on interventions with commercial brain training software, with the broad Feuerstein intervention aimed at structural cognitive modifiability. Two approaches to evaluation are discussed. This paper suggests an alternative set of criteria for evaluating effectiveness to the "gold standard" traditional clinical experimental design criteria used in the Simons paper. This is the criteria put forward by Sternberg for evaluating intellectual skill training interventions. It applies these Sternberg criteria systematically to the review by Simons and colleagues and to the Feuerstein program, citing a wide range of research literature on the Feuerstein program.

Questo contributo esplora la rivista della letteratura del 2016 di Simons e collaboratori sull'efficacia dei programmi di *brain training* in relazione al programma di arricchimento strumentale (PAS) Feuerstein che insegna come imparare. Si confronta il lavoro di Simons che si concentra su software "commerciali" per il brain training con la più ampia visione di Feuerstein orientata a generare modificabilità cognitiva strutturale. Il contributo discute così due diversi approcci valutativi, e presenta un set di criteri per una valutazione efficace alternativi al *gold standard* della tradizione clinica sperimentale utilizzati da Simons e coll. Si rivisitano così i criteri per valutare le abilità intellettuali di Sternberg, e si applicano in modo sistematico alla rivista di Simons e poi al metodo Feuerstein basandosi su un'ampia letteratura.

KEYWORDS

Brain training; Feuerstein; Sternberg; effectiveness criteria; Feuerstein Instrumental Enrichment.
Brain training; Feuerstein; Sternberg; criteri di efficacia; Programma di Arricchimento Strumentale Feuerstein.

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In 2016 David Tzuriel, a research leader with the Feuerstein approach, drew my attention to the paper then just published by Simons, Boot, Charness, Gathercole, Chabris, Hambrick and Stine-Morrow (2016) named «Do brain training programs work?» The authors called their review 'a comprehensive review of the brain-training literature' (p.103). Contemporaneously, Tzuriel was advising me on the planning of my book titled *Thinking about the Teaching of Thinking: The Feuerstein Approach* eventually published 2020. He wrote «I do suggest that you read the following paper (almost a book) and see what you can take from it and include in the modified draft that you sent me» (personal communication 23/12/2016). I decided that it was important to clarify the relationship between the issues and findings of this Simons et.al. (2016) review and the issues and those of the Feuerstein cognitive enhancement program, to avoid a superficial generalisation of the conclusions from the findings of this 2016 review to the Feuerstein program. I attempt this in this chapter.

1. The two types of approaches

The Simons et. al (2016) review, although considerable, has a narrow focus on "brain-training" programs which involve brain training interventions 'with commercial brain-training software' (p. 173). These include *Lumosity* (a personalised brain-training program); *Posit Science* (operating in the digital-brain-health market); and *Cogmed* (using working memory software). Detailed attention is also given to the "Advanced Cognitive Training for Independent and Vital Elderly (*ACTIVE*)" trial because of its scope and impact on the brain training literature, although it involves face to face small group training with a range of three intervention conditions, including memory and reasoning, speed processing, and application of strategies to real life tasks. Also covered is the *Fast ForWord* digital program aimed at developing reading skills but involving practice in «auditory and visual discrimination, attention, and working memory» (p. 139).

Except for the *ACTIVE* trial, the brain training interventions reviewed by Simons. et. al. focus on a narrow range of cognitive abilities, while purporting to aim at providing what the reviewers label as «a quick way to enhance cognition» (p. 173), including their broad cognitive benefits such as improved real-world performance. In personal communication with me, Professor Daniel Simons wrote «Our paper's scope was defined as a review of computerised "brain training programs" and the commission explicitly excluded other forms of education intervention» (personal communication 10/11/2020).

In sharp contrast, the Feuerstein cognitive enhancement program, called 'Instrumental Enrichment' has as its main aim "structural cognitive modifiability". The first key publication on the program was a book by Feuerstein, Rand, Hoffman and Miller (1980) called *Instrumental Enrichment: An Intervention program for Cognitive Modifiability*. In line with this aim, the intervention involves complex directly mediated (face to face) interactions over a considerable period (usually two years) and covering a broad range of cognitive and metacognitive processes. The second edition of this publication by Feuerstein, Feuerstein, Falik and Rand (2006) still has "cognitive modifiability" in its title.

This complex interactive approach, with its related tools addressing not only the learner, but the mediator and the task, and considering the modifying environment, fits with what has been termed a 'social model of disability' in which the learning needs and challenges are seen as wider than those confined to the lear-

ner. This compares with a 'medical model of disability', where the learning needs are seen as within the learner. In the Simons et.al. (2016) review, the very term "brain training" suggests a focus on "within-individual" brain functioning which needs "fixing", a medical model of cognitive enhancement.

2. The two sets of criteria used for evaluation of effectiveness

Simons et. al. (2016) state clearly that their review uses what they call 'the gold-standard design' to specify the criteria they will use to assess the evidence of brain-training benefits. They state 'when evaluating the effectiveness of any treatment, drug or intervention, the gold standard is a double-blind, placebo-controlled, randomized clinical trial. In that design, participants are randomly assigned to a treatment group or an appropriate control group; they do not know whether they have received the treatment or the placebo, and the person conducting the testing does not know whether any particular participant is in the treatment or the control condition' (p. 114).

This set of criteria is stringently drawn upon throughout the review, although awareness is shown in the concluding recommendations of the difficulties of following these gold standard requirements with most brain-training interventions. For example, the reviewers state that «in such interventions, participants cannot be blind to the nature of the intervention; they know which tasks they are doing» (p. 164). This "gold standard design" uses a narrow medical model for research, based on laboratory experimentation, with even medical terms used through the review such as «Dosing» (p. 164) for length of the intervention.

On the other hand, the reviewers also recommend developments which cannot be easily limited to tightly controlled laboratory-controlled interventions, when they state: «to understand the practical consequences of cognitive improvements, more research is needed on the ways in which cognitive skills are applied in the contexts of work, education, and daily life» (p. 169). They draw attention to the issue of possible difficulty in generalisation from such a 'gold standard' design.

I would like to outline an alternative set of criteria put forward by Robert Sternberg, for what he calls "intellectual skills training", as early as 1983. These criteria or 'pre-requisites' are informed by his wide knowledge of interventions for intellectual skills training, including the Feuerstein cognitive enhancement program. They are detailed below.

3. Sternberg's seven criteria for evaluation

Robert Sternberg presents key evaluation criteria, for interventions used for intellectual skill training. These criteria cover not only the "empirical evidence" for the effectiveness of the intervention, looked at in depth in terms of effectiveness over facets of training, over time, and with transfer. They also cover key other aspects of the intervention. Seven of these criteria are detailed below.

3.1 Theory base

The first criteria is named «the program should be based on a theory of intellectual performance specifying mental processes that have received experimental verifi-

cation outside the context of the training program» (p. 6). The Simons et.al. (2016) reviewers of "brain training" interventions comment in their recommendations that there need to be theoretical developments, as the field «is grounded mostly in implicit theories of how cognitive capacities support everyday functioning» (p. 161). They feel that «cognitive-intervention research needs more complete translational theories that meaningfully connect lab-based measures to objective measures of everyday performance» (p. 161).

In contrast, the Feuerstein cognitive enhancement program was informed in its structural development by the Feuerstein Theory of Mediated Learning Experience. This sees human mediation, operationalised as Mediated Learning Experience criteria, to be essential to cognitive enhancement.

Shayer and Beasley's (1987) early critique of research on the Feuerstein Instrumental Enrichment program includes a detailed analysis of Feuerstein's Theory of Mediated Learning Experience, which they see as underpinning Instrumental Enrichment. They also draw attention to Feuerstein's seven-parameter Cognitive Map, suggesting that three parameters of this Map are testable, in evaluation of Instrumental Enrichment. i.e., the modality, cognitive operations, and phase. They state that «the phase parameter engenders the explicit meta-cognitive strategies which occur in every IE lesson» (p. 103). They also in this article report on their own research with Feuerstein Instrumental Enrichment which looks at these three parameters.

3.2 Sociocultural relevance

The second criteria is «the underlying theory of intellectual performance should be socio-culturally relevant to the individuals who are exposed to the training program based on the theory» (p. 7). Simons et. al. (2016) pay little attention to sociocultural issues, except for an understanding that «brain-training products target some of the most vulnerable populations» (p. 169). In an affirmation of the *ACTIVE* trail, the «largest brain-training intervention to date» (p. 124) which «conformed to many of the best practices for intervention research» (p. 125) the reviewers note that «The sample was large, ethnically and geographically diverse […] 28% per non-White […] and systematically screened for conditions that might reduce plasticity or interfere with participation in the training» (p. 125). However, no mention is made of how appropriate the intervention was for the participants with differing cultural backgrounds.

In my experience, cognitive interventions with vulnerable groups frequently involve learners with differing cultural backgrounds. This was particularly so with the series of rigorous research projects I and colleagues carried out with a variety of vulnerable learner groups in New Zealand, using the Feuerstein cognitive enhancement program. In reporting these studies for educators, in Howie (2020), I discuss key ideas by Feuerstein and Kozulin on the concepts of cultural difference and cultural deprivation which underpin the Feuerstein approach and outline important cultural issues in intervention and evaluation of Instrumental Enrichment. In my major study with M ori adolescents and in partnership with their M ori teachers, particular care was taken to explore the relevance of the Feuerstein approach for these participants (Howie, Richards and Pirihi, 1993), including from the viewpoint of the M ori teachers of the program.

3.3 Provision of both executive and non-executive training

The third criteria is «the programme should provide explicit training in both executive and non-executive information processing, as well as interactions between the two kinds of information processing» (p. 9). Sternberg's (1979) landmark paper on "The Nature of Mental Abilities", clearly distinguishes between executive processing (meta-components) and non-executive processing (components).

The reviewers in the Simons et.al. (2016) paper seem to have mixed views on these criteria. Sometimes these reviewers appear to see executive training as a separate intervention from a 'cognitive intervention', and to be looking for a purely 'cognitive intervention' outcome. For example, in discussing the randomised controlled trial by Bowie, Gupta, Holshausen, Jokic, Best and Milev (2013) they state «the cognitive intervention included substantially more than just the brain-training games; it also included group therapy, training of strategic self-monitoring, [underlining mine] bridging to daily life, and homework. Consequently, it is not possible to isolate the effects of cognitive intervention from those of other aspects of training» (p. 149). However, at other times they do not separate these types of interventions out to this extent. For example, they discuss the *ACTIVE* trail as having three 'intervention conditions' (reasoning and memory training; speed of processing training; and control of no contact) and appear to see the first two as cognitive interventions.

In contrast, in a later discussion of the *Cogmed* intervention, for children with ADHD, considerable attention is given to discussing why the working memory tasks involved might improve executive control. The reviewers state «working memory performance is closely linked to other executive-control functions, including selective attention and inhibitory control, sustained attention, and non-verbal reasoning. Thus, *Cogmed* training might be expected to enhance performance on tasks that tap these functions» (p. 146).

Sternberg (1984) describes the Feuerstein Instrumental Enrichment cognitive enhancement program as being based on «Feuerstein's theory of intelligence, which emphasizes what I refer to as meta-componential and performance-componential functioning» (p. 40). Sternberg sees the program as aimed at improving the cognitive functions relating to input, elaboration and output phases of information processing. A careful look at the list of cognitive functions/dysfunctions which form this Feuerstein tool, aimed at analysing the learner's learning strengths and needs in phases of 'the mental act' indicates a mix of both executive and non-executive cognitive functions, but with a strong focus on executive functions, such as ability to define a problem, and ability to engage in planning behaviour.

3.4 Responsive to motivational needs

Sternberg's fourth criteria is that «the program should be responsive to motivational as well as to intellectual needs of the students it trains» (p. 10). In the Simons et. al. (2016) review only very occasional mention is made of such needs in describing an intervention. It is mentioned that the *ACTIVE* trail involved feedback to both the individuals and the groups involved. The Lumosity intervention gives feedback to the game players on their brain "fitness", and there are several mentions of motivation-related outcome measures used, such as a self-reported well-being measure used in some of the Lumosity studies.

Sternberg (1985) acknowledges that the Feuerstein Cognitive Enhancement program has a strong focus on motivational factors, probably as it was developed

for learners experiencing challenges and failure in the school system. Tzuriel has written in depth about these motivational aspects, which need to be addressed through Mediated Learning Experience (Tzuriel, Samuels and Feuerstein, 1988).

3.5 Sensitive to individual differences

Sternberg's fifth criteria is that «the program should be sensitive to individual differences» (p. 10). Simons.et.al (2016) also see this as important, stating that «papers should describe the personal relevance of the effects. How much better will I perform on tasks like the outcome measures? » (p. 166). In this field of brain training, in which consumer choice is so important, the reviewers state «consumers want to know if an intervention will work for them, personally. Interventions may not affect everyone in the same way […] tailoring training to account for individual differences would be ideal,

difference factors mediate or moderate the effectiveness of training» (p. 161). Unfortunately, the focus by the reviewers on the use of group control design yields little possibility for identification of such individual information.

In a later paper, Sternberg (2000) discusses in more depth the importance of exploring both group and individual difference in response to a cognitive intervention, including exploring how an individual responds to each component of a cognitive enhancement program. We (Howie, Thickpenny, Leaf and Absolum, 1985; Thickpenny and Howie, 1990; Howie, Richards and Pirihi, 1993) used in our series of rigorously evaluated Feuerstein Instrumental Enrichment program interventions both a group control design and a single subject experimental research design. The later was an adaptation of Hersen and Barlow's (1976) repeated measurement over time design which allows for

exploration of variability of behaviour and learning by a single "case" over time and components of a program. This allowed for rich information about individual response to each "Instrument" of the Instrumental Enrichment program. It explored level of functioning on key instruments used in the training, with each instrument addressing a distinctive set of cognitive/metacognitive skills and strategies.

3.6 Links between training and real-world behaviour

Sternberg's sixth criteria states that «the program should furnish links between the training it provides and real-world behaviour» (p. 11). The Simons.et.al. (2016) review expresses considerable concern that the cognitive programs it reviews make claims for broad real-world problem-solving advantages, but rarely show evidence of this. For example, they state in their discussion «The limited evidence in the literature for transfer from brain-training interventions to real-world outcomes stands in strong contrast to the marketing claims of many brain-training companies […] almost none of the cited studies reported tests of the benefits of training on the marketed products for objectively measured real-world performance» (p. 158-159).

The Feuerstein Instrumental Enrichment program has an inbuilt requirement for "mediation" to real world (including academic) problem solving through "bridging" of skills and strategies. Also required as part of this mediation is the drawing out of "principles" from each lesson, which can be applied to real life problem solving at increasingly abstract levels. Evaluation of the Feuerstein Instrumental Enrichment intervention also requires and finds challenging the identification and

use of appropriate real-life problem-solving measurement tools. A wide range of attempts have been made in the Feuerstein research literature to do this. For example, in their extensive study with Feuerstein's Instrumental Enrichment program Arbitman-Smith, Haywood and Bransford (1984) describe the testing for mastery at two levels of transfer, what they call 'domain specific transfer' and 'domain independent transfer'. They chose for 'domain independent transfer' problems from the more advanced Instruments which the subjects had not already studied, and problems from real life.

Bachor (1988) makes an important contribution to this issue of generalisation in his study focus on near and far transfer of Feuerstein's Instrumental Enrichment program with adults with learning disabilities. To determine the extent of transfer, he selected or designed measures relating to Feuerstein's Cognitive Map. The near transfer tasks were based on four aspects of the Cognitive Map: content, level of complexity, level of abstraction, and level of efficiency, and were a shopping task and a boxes task. In contrast, a Social Education Test and a Vocational Checklist were elected as measures of far transfer. In his UK study with Feuerstein Instrumental Enrichment Blagg (1991) incorporated a map reading skill assessment, which he saw as reflecting «abilities to gather, organise and interpret information» (p. 67). Howie, Richards and Pirihi (1993), in a Feuerstein Instrumental Enrichment program intervention with M ori adolescents, used an adaptation of the Stanford-Binet (1960) Year XIII Plan of Search Task as a real-world problem-solving task.

3.7 Empirical evaluation including durability and transferability

Finally, Sternberg's seventh criteria states «The program should receive careful empirical evaluation that assesses both durability and transferability of training, and the evaluation should assess facets of the training program as well as the training program as a whole» (p.11). Simons' et.al. (2016) review certainly focuses on empirical evidence concerning transferability of training, though less consistently on durability and the assessment of facets of the program. Neither of these aspects are listed in the summary section «Problems with intervention studies and their implications» (p. 171). Moreover, the "gold standard" model of research which they applaud does not mention these aspects.

The Feuerstein cognitive enhancement program has as its aim "structural cognitive modification" so both durability and transferability are key issues in demonstrating its effectiveness. It is widely considered in the Feuerstein research literature that this aim of "structural cognitive modifiability" will be demonstrated to be affected by long term follow up data showing an increasing advantage in cognitive functioning to the subjects receiving the Feuerstein cognitive enhancement program, as compared to control subjects. This "snowballing" effect, (divergent effects in gains after the termination of the intervention over extended periods of time), is because the structural cognitive modification allows subjects to learn effectively from ongoing real-world stimulation. For example, such a 'snowballing' effect was found in the early main Feuerstein large scale study with Feuerstein's Instrumental Enrichment program, reported by Feuerstein, Rand, Hoffman and Miller (1980). The study involved a two year follow up (possible through army service measures) which showed an increasing divergence in cognitive scores over time. A replication large scale study was carried out in Venezuela by Ruiz and Castaneda (1983) and reported by Savell, Twohig and Rachford (1986). They used a matched pair follow up evaluation of the original Feuerstein

intervention and a similar "snowballing" effect was found, with a very culturally different (and mixed socio-economic) population.

A unique long-term study on the effects of the Feuerstein program was carried out by O'Hanlon (2011) with lower attaining students aged 11/12 in Northern Ireland post primary schools. Pupils from 5 experimental schools were matched with pupils from 5 similar control schools, and received the Feuerstein program for three years. (The control group received extra English.) Evaluation included a long-term evaluation five years after the programme began. This consisted of standardized achievement data obtained from National GCSE evaluation or its equivalent. The achievement differences between experimental and control groups' GCSE English results were remarkable, with 33.3% of the original Feuerstein group achieving a Key Stage 4c level or above, while only 7% of the control group did (despite the latter receiving extra English).

A key issue in cognitive intervention is the length of the intervention and how this relates to transfer or generalisation of skills and strategies. The cognitive interventions covered by the Simons et. al. (2016) review were generally particularly short term. For example, studies cited on the use of the *Luminosity* program were implemented for 20 hours, *PositSci*ence for 14/50 hours, Klingberg's working memory training for 12 – 20 hours, *Cogmed* for 5 weeks, and *FastforWord* for 30-100 hours. The *ACTIVE* trial, considered important by the reviewers, had an initial 10 hours of training followed by two short bursts of booster training at 11 months and 3 years follow ups.

Simons et.al. (2016) reviewers note that for the dual-back *Memory* training, which involved 8, 11, 17 or 19 sessions, «the more training the participants received the greater was the gain in the measure of Gf[1] (either the Ravens or a similar reasoning task, the Bochva matrices task) » (p. 150). The reviewers early in their article devote a section to transfer issues. They note that «the general lack of evidence for the development of cognitive capacities based on short-term experiences of the sort that can be studied in the lab» (p. 112).

In contrast, the Feuerstein Instrumental Enrichment program is unique among cognitive training programs in its aim of 'structural cognitive modifiability' and the requirement of intense and sustained intervention, over two years, to obtain this.

In one of our early New Zealand studies (Thickpenny & Howie, 1990) with the Feuerstein program with adolescents with severe hearing disabilities, the researcher, John Thickpenny, was required because of ethical issues to use a design which allowed for a comparison of effects of length of training with Instrumental Enrichment, an issue which had already been identified as an important issue in the Feuerstein research literature (e.g. by Bradley, 1983). The wide range of outcome measures used in Thickpenny and Howie (1990), and the careful identification of them as having either "high sensitivity to training" on the Feuerstein instruments (i.e. near transfer) and 'low sensitivity' to training (i.e. far transfer), allowed for the finding that the Group One subjects who were exposed to Instrumental Enrichment for a longer period of time obtained a larger number of significant shifts on the far transfer measures than the Group Two subjects.

1 GF is fluid intelligence, indicating transfer.

4. Conclusions

This article has drawn comparisons between the Simons et.al (2016) review of studies aimed at 'brain training' and the Feuerstein Instrumental Enrichment program for cognitive enhancement. In particular, the article offers an alternative set of criteria for evaluating the effectiveness of such approaches to cognitive training and enhancement. It also offers some insights into intervention practices which are likely to enhance the effectiveness of the Feuerstein approach to cognitive enhancement. In line with the Sternberg effectiveness criteria these include:

- The quality of the mediation underpinning the intervention.
- The recognition of the importance of the complex factors which interact to enhance meeting of the learner's needs, including not only the mediation, but the task demands, and the requirements of the inclusive context.
- The need to ensure that cultural learning strengths, values and needs are recognised and met in a partnership way.
- The interacting cognitive, metacognitive and motivational needs should be addressed in the intervention in a partnership way, to give maximum learner control over their own learning.
- The acknowledgement of and attention to unique individual needs while using this intervention in a whole class and group inclusive way.
- A strong focus on drawing out increasingly abstract principles from the lesson, along with generalisation or 'bridging' to real life problem solving which draws on the learner's own experiences.
- An understanding of the importance of the length of the intervention for structural cognitive modification.

All children have the right to fulfil their learning potential (United Nations 1989), and interventions for the teaching of thinking can facilitate this. Such interventions require resources, time and effort. It is important to ensure that interventions chosen meet the criteria set out by Sternberg, and follow a social rather than a medical model. This paper has shown the Feuerstein Instrumental Enrichment program to be a clear example of an intervention which meets these criteria. This is supported by Sternberg's recent (2015) statement that in his view, Feuerstein, Piaget and Vygotsky, along with Luria, stand alone in the scope and power of their contribution to the teaching of learning and thinking.

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