The development and testing of a classroom-based intervention targeting working memory, attention and language skills in 4-5 year old children: A cluster randomised feasibility trial.

SHORT REPORT

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CONTENTS

EVIDENCE BRIEF

Why did we start?

Internationally, there has been debate around the best models of Speech and Language (SLT) provision for children who are at risk of language disorders, particularly those from areas of social disadvantage (SD). SLTs and other health professionals (HPs) provide collaborative, classroom-based interventions but there is a lack of research-based evidence for this approach, raising questions about whether they waste limited resources. Working memory (WM) is a cognitive skill that is associated with attention and language skills. There has been speculation that embedding WM training within typical educational activities, may improve children's WM skills and produce transfer effects to real-world skills such as attention and language. This study aimed to develop and test a classroom-based intervention targeting WM to enhance attention and language skills in 4 - 5 year olds from areas of SD.

What did we do?

This was a mixed-methods, multi-phase study that included: 1) A systematic review of the effectiveness of non-computerised WM interventions; 2) A qualitative study with HPs and teachers to investigate the barriers and facilitators to the intervention implementation; 3) Co-production work with a group of HPs, teachers and parents of 4-5 year olds; and 4) A cluster randomised feasibility trial to explore the feasibility and acceptability of the novel intervention and determine whether it would be possible to carry out a full-scale trial of its effectiveness.

What answer did we get?

A synthesis of the evidence from the systematic review and the qualitative study with the experience of HPs, teachers and parents resulted in the co-production of 'Recall to Enhance Children's Attention, Language and Learning' (RECALL). It is a six-week, classroom-based intervention that targets WM. It is designed to be delivered once weekly by HPs and twice weekly by teachers. The feasibility study indicated that it would be possible to conduct a full-scale trial of the effectiveness of RECALL. There were mixed findings regarding the fidelity of the intervention delivery and the acceptability of the tasks. In the whole class setting, there was also a dilution of the dose (number of practice items) accessed by individual children, particularly those who may benefit most from intervention.

What should be done now?

Policy-makers and practitioners in school-based services should reflect on the clinical and cost effectiveness of whole-class (universal) interventions, considering the potential dilution of the potency of interventions in this setting. Small group (targeted) interventions may be more beneficial for the most at risk children but further research is needed. RECALL should be modified to enhance its acceptability, packaged as a small group intervention and tested in a full-scale trial. Teachers should be trained on the theoretical underpinning and delivery of the intervention to increase the fidelity of implementation.

BACKGROUND

In areas of social disadvantage (SD), high proportions of children present with impoverished language skills on school entry (Elliott 2011). These children are subsequently at risk of poor school performance, restricted employment prospects and ultimately poor physical and mental health (Conti-Ramsden *et al.* 2016, Roulstone *et al.* 2011). To address this, Speech and Language Therapy and other health services provide early intervention in schools through collaborative, classroom-based approaches. However, there is a lack of research-based evidence for the effectiveness of such interventions (Ebbels *et al.* 2019). There are many questions about the optimal levels of dosage for interventions in the area of child language and development (Justice 2018) and there is a need for creative therapeutic approaches (Norbury 2017).

In Northern Ireland (NI), policy has emphasised the need for early intervention and integrated service delivery (Bengoa 2016, DHSSPS 2014, HSCB 2011) The Regional Integrated Support for Education (RISE) teams are based in the Health and Social Care Trusts and support children in mainstream schools (DENI 2006). The teams include speech and language therapists (SLTs), occupational therapists (OTs), physiotherapists (PTs) and social, emotional and behavioural specialists (SEBs). The majority of referrals to the teams are for year one pupils (4-5 year olds) in LSES areas who have difficulties with attention and language skills (Harron & Dickson 2013). The RISE teams developed a whole class intervention that specifically targets these skills but it has not been robustly evaluated and lacks a clear theoretical underpinning.

Working memory research and gaps in knowledge

Working Memory (WM) is a cognitive skill that underpins attention (Bunting & Cowan 2005, Cowan *et al.* 2006) and language learning (Baddeley *et al.* 1998). The implication of the symbiotic relationship between WM, attention and language is that targeting WM as an underlying skill may produce improvements in these real-world skills (Archibald 2018). Most research into WM interventions has focused on the effectiveness of computerised training packages. The therapeutic value of this approach has been debated due to the consistently inconsistent evidence for transfer effects i.e., the generalisation of positive effects on trained tasks to other untrained tasks (e.g., Melby-Lervåg *et al.* 2013). This has led to suggestions that embedding WM training within the educational activities that depend on it may be a more ecologically valid and effective approach (e.g., Dunning & Holmes 2014). However, there has been limited research into the effectiveness of WM interventions applied with young children in everyday contexts. Furthermore, to date the literature has focused on the cognitive benefits of WM training (Jaeggi & Buschkuehl 2014, Schwaighofer *et al.* 2105). There has been little consideration of the contextual factors associated with the delivery of

WM interventions in real-life settings such as schools where controlling the quality, dose and fidelity training may be challenging (Jaeggi & Buschkuehl 2014).

AIMS AND OBJECTIVES

To develop and test a classroom-based intervention targeting working memory to enhance attention and language skills in 4-5 year old children from areas of SD.

To achieve the research aims this study had four objectives

1. To conduct a systematic review of non-computerised interventions that target WM in children's everyday contexts.
2. To explore the contextual factors that may impact on the development and testing of a novel classroom-based intervention targeting WM, attention and language skills in 4-5 year olds.
3. To synthesise the evidence-base for what works in WM interventions with the knowledge, skills and experience of HPs, parents and teachers and to co-produce an intervention deliverable by the RISE teams and teachers in schools within areas of SD.
4. To examine the feasibility and acceptability of the intervention and the factors that impact on the delivery, dosage and potential effectiveness of classroom-based interventions.

METHODS

This study employed a mixed-methods, multi-phase design (Creswell & Plano Clarke 2011) using both qualitative and quantitative components. These were framed within the Six Steps in Quality Intervention Development (6SQuID) model (Wight *et al.* 2016) that builds on the Medical Research Council guidance on developing complex interventions (Craig *et al.* 2008). Figure 1. provides an overview of the study design and methods. There were 4 main phases in the study: 1) systematic review; 2) a qualitative study 3) intervention co-production; and 4) a cluster randomised feasibility trial.

This study design and the methods employed were underpinned by complexity theory and an ecological perspective, recognising that complexity is a property, not just of an intervention, but of the context (or system) within which it is implemented (Hawe 2015). This meant there was a need to develop an individual theory of change (how and why the intervention may impact on WM, attention and language) and a systems theory of change (how it may be implemented in the real-world context of the interacting systems of the RISE teams and schools). To explore the intervention context fully, the socio-ecological model (McLeroy 1988) was used at several stages in the study. Logic modelling was also used as a tool to understand how the intervention might work (Kellogg Foundation 2004).

Figure 1. Study design and methods based on the Six Steps to Quality Intervention Development Model (6SQuID) (Wight et al. 2016)

Step 1: Understand the problem and its causes

- Audit of referrals to RISE teams
- Consultation with RISE managers
- Literature evidence

Step 2: Clarify which causal and contextual factors are malleable

- **A systematic review of** the effectiveness of non-computerised working memory interventions with 4- 11 year olds (Rowe *et al.* 2019a)
- **A qualitative study** to examine the contextual factors that may impact on intervention implementation. Focus groups were conducted with clinicians from the RISE teams (*n*= 13), teachers (*n*= 10) and parents (*n*= 6) of year one children from schools in areas of social deprivation

Step 3: Identify how the intervention will work (change mechanisms)

- The mixed-methods evidence from the systematic review and the qualitatiev study was integrated to develop:
- an individual theory of change about how and why a novel, classroom-based intervention will impact on children's WM skills; and
- a system theory of change about how contextual factors will support the implementation of the intervention in practice
- An initial logic model of the intervetion theory and its implementation was developed

Step 4: Identify how the intervention will be delivered

- **Co-production** with one group of HPs from the RISE teams (n= 7); teachers (n= 2) and parents (n= 2). 3 full-day workshops took place over a 3-month period to develop the intervention. The logic model of the intervention theory and implementation was modified and an interim model was agreed

Step 5: Test and refine the intervention on a small scale

- Based on the co-production work, a prototype of the intervention was produced. This was refined through expert and practitioner review

Step 6: Collect evidence to justify rigourous evaluation

- **A three-arm cluster randomised feasibiltiy trial** involving 6 schools in areas of SD in Northern Ireland. Two classes received the experiemental intervention (RECALL), 2 received an exisiting intervetnion used by the RISE teams and 2 received education as usual (no intervention).
- Outcome measurement: 10 children in each class (*n*=60) were selected for outcome measurement including direct assessment of: WM, attention, lanuguage; a teaceher rating of behvaoiur in the classroom; and a parent rating of communication skills at home.
- Process evaluation: this included observations of the fidelity of the intervention delivery; and semi-structured interviews with the health professionals and teachers.
- The logic model was refined to reflect a greater understanding of how the intervention works in the real-life setting of the classroom

PERSONAL AND PUBLIC INVOLVEMENT (PPI)

Personal and public involvement was a key component throughout this study. The research question was refined through a focus group with year one teachers (*n*= 4) and classroom assistants (*n*=2) and consultation with parents of children with developmental difficulties (*n*= 68). A Research Advisory Group was established at the start of the study comprising: RISE team managers (*n*= 2); senior staff from the Education Authority NI; a school principal; a year one teacher; and parents of children with language difficulties (*n*=2). Face-to-face meetings were held with this group 3-4 times per year throughout the doctoral study to support an ongoing understanding of the contextual factors that could impact on the conduct of the research and intervention implementation. Notably, parents of children with language disorder were part of the co-production group that developed the novel intervention and their role was integral to this process.

FINDINGS

The key findings from the four major phases in the study are summarised below.

1. Systematic review

The systematic review of the effectiveness of non-computerised interventions with 4- 11 year olds included eighteen papers were that had implemented a range of non-computerised WM intervention approaches. Both direct training on WM tasks and practicing certain skills that may impact indirectly on WM (physical activity, fantastical play and inhibition) produced improvements on WM tasks, with some benefits for near- transfer activities. The common ingredient across effective interventions was the executive- loaded nature of the trained task. This means tasks that require higher level cognitive processing and attentional resources, not just the passive storage of information in short-term memory. Relatively short interventions (5-8) weeks were effective. The implication of these findings for the to-be-developed intervention were that all of the tasks should be executive-loaded in nature.

2. Qualitative study

The qualitative study explored the factors that may impact on the development and testing of the to-be-developed classroom-based intervention: 1) HPs' and teachers' perceptions of WM and its associations with attention and language; and 2) the potential barriers and enablers to the delivery of the programme in the mainstream school setting. The key findings were that HPs and teachers had limited awareness of WM or the implications of low WM for children's learning. Their current practice is eclectic and is underpinned by lay theories including: a belief in a transdisciplinary model (interventions combining motor, sensory and language tasks); and a belief that children learn when tasks are functional and fun. HPs' and

teachers' intervention approaches and dosage are based on contextual factors, especially the demands of the curriculum and the classroom environment. The implications of these findings for the to-be-developed intervention were that HPs and teachers involved would benefit from training in: WM theory; the research evidence regarding the effectiveness of WM training; and the importance of dosage in intervention research and practice. However, the study also suggested that, due to resource constraints, it was unlikely that teachers could be released for training on the novel intervention. The evidence indicated that the positive working relationship between the RISE teams and schools could be harnessed in the delivery of the intervention i.e., the HPs from the RISE teams could work collaboratively with the teachers to model the intervention for them in the classroom.

3 Intervention Co-production

Evidence from the systematic review and the qualitative study were integrated into a two-stranded theory of change:

• *At the individual level: executive-loaded tasks repeated 3 times per week for 6 weeks can benefit WM and produce near- and far-transfer effects to attention and language.*

• *At the systems level: joint delivery by education staff and trained members of the RISE teams, who will model the sessions for the teachers, will support the implementation of the classroom-based intervention.*

This underpinned the co-production of the intervention. Three full day workshops were held with one purposefully sampled group of HPs, teachers and parents. The aim was to synthesise the evidence-base for what works in WM interventions (the systematic review findings) with the participants' knowledge, skills and experience of practice in the real-world context. This resulted in the co-production of Recall to Enhance Children's Attention, Language and Learning (RECALL). It consists of six, forty-minute sessions delivered in the classroom once weekly by trained members of the RISE teams and repeated a further two times per week by the class teacher (18 sessions in total).

The evidence-based, executive-loaded tasks in RECALL include:

• Two direct executive-loaded working memory tasks: listening recall and odd one out (Henry *et al.* 2014) with a specified dose of 11 practice items per session of each task

• Phoneme awareness training e.g., identifying the first sound in a word (van Kleeck *et al.* 2006) with 10-15 minutes of practice per session.

• Fantastical play was also integrated into RECALL through the use of a fantastical theme for each session e.g., superheroes (Thibodeau *et al.* 2016). The fantastical theme is introduced each week by a puppet with the idea that he takes the children on an adventure to a fantastical land.

RECALL includes a comprehensive facilitator manual including the theory underpinning the intervention, detailed session plans and all of the materials required to deliver the intervention.

4 Cluster randomised feasibility study

The feasibility study aimed to examine the feasibility and acceptability of RECALL and the factors that impact on the delivery, dosage and potential effectiveness of classroom-based interventions. Six schools in areas of SD were recruited successfully and two were randomly allocated to each arm of the trial: RECALL, an existing intervention targeting attention skills (not underpinned by WM theory); and education as usual (no intervention). In each school, one class in year one (4-5 year olds) participated.

From the 157 children in the participating classes, parental consent was obtained from 113 (72%). The total sample (n= 60) included: 1) children about whom teachers had concerns around listening and communication skills (n= 22); 2) children with diagnosed developmental or learning difficulties (n= 12); and 3) typically developing children who do not have any identified listening and communication problems as recognised by the teachers *(n$=* 26). The following outcome measures were administered pre- and post-intervention: standardised assessments of WM, language and attention skills; a teacher rating scale of attention in the classroom; and a parent rating scale of functional communication skills.

There was good compliance to the implementation of RECALL regarding the total number of sessions (95%) and the number of practice items delivered. There were mixed findings regarding the acceptability of the RECALL tasks. The participants liked the listening recall, phoneme awareness and fantastical play components. The odd one out task was challenging to administer and was modified significantly in one of the schools. Fidelity to the intervention delivery thus varied between the two RECALL schools (76% versus 45%). In both schools, the children became unmotivated and inattentive during this task. Hence, the treatment intensity accessed by individual children, particularly those with attention difficulties who may benefit most from RECALL, was diluted from the evidence-based dosage specified in the intervention. The qualitative data indicated that a greater understanding of the theory underpinning RECALL would have enhanced the teachers' fidelity to its delivery. Figure 2 shows the impact of various factors on the dosage of whole-class interventions.

CONCLUSION

The trial processes could be easily scaled-up into a future definitive trial to evaluate the effectiveness of RECALL. The intervention could be refined to increase its acceptability to HPs and teachers. In a future, definitive trial of RECALL, teachers (not just the HPs) should be trained on its theoretical underpinning to enhance the fidelity to the intervention protocol.

PRACTICE AND POLICY IMPLICATIONS AND RECOMMENDATIONS

Policy-makers and practitioners in school-based services should reflect on the clinical and cost effectiveness of whole-class (universal) interventions, considering the potential dilution of the potency of interventions in this setting. Small group (targeted) interventions may be more beneficial for the most at-risk children but further research is urgently needed to investigate this further. RECALL could be modified to enhance its acceptability, packaged as a small group intervention and tested in a full-scale trial. Teachers should be trained on the theoretical underpinning and delivery of the intervention to increase the fidelity of their implementation.

Figure 2. The factors impacting on dosage in classroom-based interventions
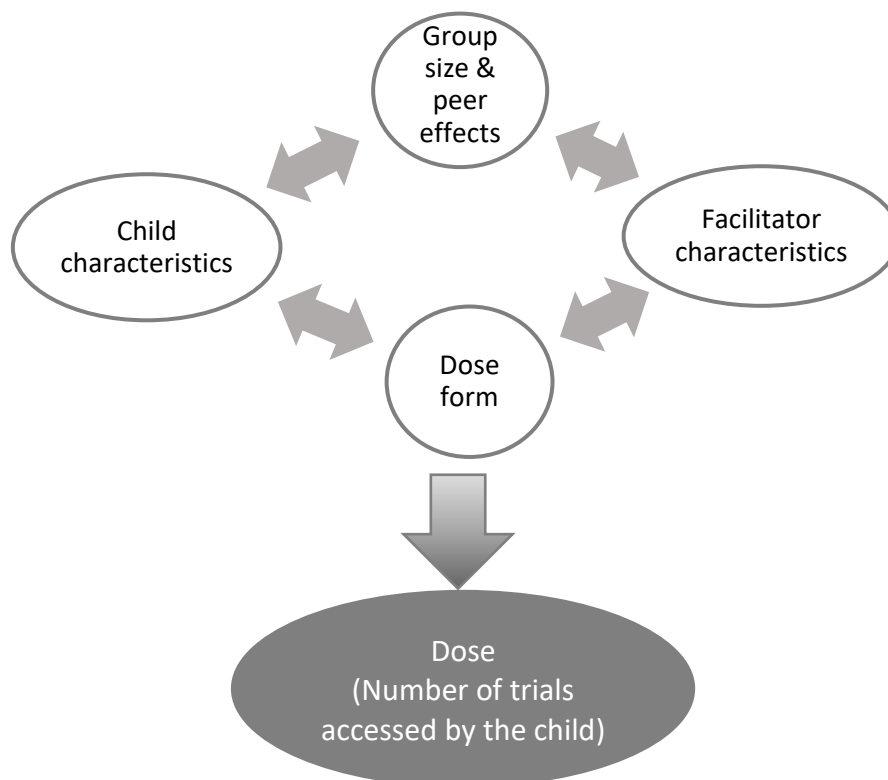
PATHWAY TO IMPACT

This study addressed gaps in both WM and SLT research about the impact of the whole-class context on the delivery and dosage of classroom-based interventions. Through the explicit application of individual and systems theories of change, a theoretically-underpinned, evidence-based intervention was developed and tested. This study has opened up the opportunity for ongoing collaboration and future research partnerships with Dr Joni Holmes (Cambridge) and Prof Lucy Henry (London) including a potential grant application for a full-scale, multi-centre cluster randomised trial of RECALL. The findings have been disseminated nationally and internationally through written publications and conference

presentations. Two papers have been published in international, peer reviewed journals: the systematic review (Rowe *et al.* 2019a) and the study protocol for the feasibility trial (Rowe *et al.* 2019b). Two further papers have been written for publication. Oral and poster presentations were given at: the American Speech and Hearing Association (ASHA) convention (Boston, November 2018) and the RCSLT national conference in Nottingham (September 2019).

REFERENCES

Archibald, L.M. (2018) The reciprocal influences of working memory and linguistic knowledge on language performance: Considerations for the assessment of children with Developmental Language Disorder. *Language Speech and Hearing Services in Schools*, 49(July), 424-433.

Baddeley, A.D., Gathercole, S.E. & Papagno, C. (1998) The phonological loop as a language learning device. *Psychological review,* 105, 158- 173.

Bengoa, R. (2016) *Systems, not structures. Changing health and social care – full report.* Available at: https://www.healthni.gov.uk/sites/default/files/publications/ health/expert-panel-full-report.pdf [Accessed: 30 November 2016].

Bunting, M.F. & Cowan, N. (2005) Working memory and flexibility in awareness and attention. *Psychological Research*, 69, 412-419.

Conti-Ramsden, G., Durkin, K., Mok, P. L.H. Toseeb, U. & Botting, N. (2016) Health, employment and relationships: Correlates of personal wellbeing in young adults with and without a history of childhood language impairment. *Social Science and Medicine,* 160, 20-28.

Cowan, N., Fristoe, N.M., Elliott, E.M., Brunner, R.P. & Saults, J.S. (2006) Scope of attention, control of attention and intelligence in children and adults. *Mem Cognit*, 34 (8), 1754-1768.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I. & Petticrew, M. (2008a) Developing and evaluating complex interventions: new guidance: Medical Research Council.

Department of Education (DENI) (2006) *Budget 2006-08 Children and Young People Funding Package.* [Accessed: 14/07/14] Available at: http://www.deni.gov.uk/children-young-people-funding-package-2.pdf

Department of Health, Social Services and Public Safety (DHSSPS) 2014 Making Life Better – A Whole System Strategic Framework for Public Health 2013 – 2023. [Accessed: 06/10/16] Available at: https://www.dhsspsni.gov.uk/sites/default/files/publications/dhssps/making-life-better-strategic-framework-2013-2023_0.pdf

Dunning, D. & Holmes, J. (2014) Does working memory training promote the use of strategies on untrained working memory tasks? *Memory and Cognition*, 2, 854- 862.

Ebbels, S., McCartney, E., Slonims, V., Dockrell, J. & Norbury, C. (2019). Evidence-based pathways to intervention for children with language disorders. *International Journal of Language & Communication Disorders,* 54(1), 3-19.

Elliott, N. (2011) An investigation into the communication skills of long-term unemployed young men. http://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.553779

Harron, A. & Dickson, F. (2013) *Perspectives on trans-disciplinary working for children in mainstream education.* Oral presentation: Rehabilitation and Therapy Research Society conference.

Hawe, P. (2015) Lessons from complex interventions to improve health. *Annual Review of Public Health*, 36, 307-323.

Henry, L.A., Messer, D. J. & Nash, G. (2014) Testing for near and far transfer effects with a short, face-to-face adaptive working memory training intervention in typical children. *Infant and Child Development,* 23 (1), 84-103.

Health and Social Care Board (HSCB) (2011) *Transforming Your Care. A review of Health and Social Care in Northern Ireland.* Belfast: HSCB.

Jaeggi, S.M., & Buschkuehl, M. (2014) Working memory training and transfer: theoretical and practical considerations. In B. Toni (Ed.). *New Frontiers of Multidisciplinary Research in STEAM-H (Science, Technology, Engineering, Agriculture, Mathematics, and Health). Springer Proceedings in Mathematics & Health, vol 90.* Switzerland: Springer International Publishing.

Justice, L.M. (2018) Conceptualising "dose" in paediatric language interventions: Current findings and future directions. *International Journal of Speech-Language Pathology, 20*(3), 318-323.

Kellogg Foundation, W.K. (2004) *Logic Model Development Guide.* Battle Creek: W.K Kellogg Foundation.

Law, J., Charlton, J., Dockrell, J., Gascoigne, M., McKean, C. & Theakston, A. (2017) *Early Language Development: Needs, provision and intervention for pre-school children from socio-economically disadvantaged backgrounds.* London: Education Endowment Fund.

Locke, A., Ginsborg, J. & Peers, I. (2002) Development and Disadvantage: implications for early years International Journal of Language and Communication Disorders Vol 37:1

McLeroy, K., Bibeau, D., Steckler, A., & Glanz, K. (1988) An Ecological Perspective on Health Promotion Programs. *Health Education Quarterly*, 15(4), 351-377.

Melby- Lervag, M. & Hulme, C. (2013) Is working memory training effective? A meta-analytic review. *Developmental Psychology*, 49 (2), 270-291.

Norbury, C. F (2017) Editorial: New frontiers in the scientific study of developmental language disorders. *Journal of Child Psychology and Psychiatry*, 58(10), 1065-1067.

Pawson. R. & Tilley, N. (1997) *Realistic Evaluation.* London: SAGE.

Roulstone, S., Law, J., Rush, R., Clegg, J. & Peters, T. (2011) *Investigating the role of language in children's early educational outcomes.* Project Report.   Bristol: UK Department of Education.

Rowe, A., Titterington, J., Holmes, J., Henry, L., & Taggart, L. (2019a) Interventions targeting working memory in 4–11 year olds within their everyday contexts: A systematic review. *Developmental Review*, 52, 1-23.

Rowe, A., Titterington, J., & Taggart, L. (2019b) Rowe, A., Titterington, J., & Taggart, L. (2019) A classroom-based intervention targeting working memory, attention and language skills in 4-5 year olds (RECALL): study protocol for a cluster randomised feasibility trial. *Pilot and Feasibility Studies*, 5(82).

Schwaighofer, M., Fischer, F. & Bühner, M. (2015) Does working memory training transfer? A meta-analysis including training conditions as moderators*. Educational Psychologist,* 50(2), 138-166.

Thibodeau, R.B., Gilpin, A.T., Brown, M.M. & Meyer, B.A. (2016) The effects of fantastical pretend-play on the development of executive functions: An intervention study. *Journal of Experimental Child Psychology,* 145, 120-138.

Van Kleeck, A., Gillam, R.B. & Hoffman, L.M. (2006) Training in phonological awareness generalizes to phonological working memory: a preliminary investigation. *The Journal of Speech and Language Pathology – Applied Behavior Analysis*, 1(3), 228-243.

Wight, D., Wimbush, E., Jepson, R., & Doi, L. (2016) Six steps in quality intervention development (6SQuID). *Journal of Epidemiology and Community Health*, 70, 520-525.