



TALi Research Compendium

A summary of the foundational papers that establish the research of the TALi attention assessment and training software tools.

Contents

| | |
|--|----|
| Key Terms / Glossary | 4 |
| Study 01 TALi DETECT Gamified Assessment of Attention in Early Childhood: A Large-Scale Validation Trial TALi Health Pty Ltd | 5 |
| Study 02 TALi TRAIN Cognitive training as a resolution for early executive function difficulties in children with intellectual disabilities Kirk, H., Gray, K., Riby, D., & Cornish, K. (2015), Research in Developmental Disabilities | 8 |
| Study 03 TALi TRAIN Visual attention and academic performance in children with developmental disabilities and behavioural attention difficulties (part 1) Kirk, H., Gray, K., Riby, D., Taffe, J., & Cornish, K. (2016), Developmental Science | 9 |
| Study 04 TALi TRAIN Visual attention and academic performance in children with developmental disabilities and behavioural attention deficits (part 2) Kirk, H., Gray, K., Riby, D., Taffe, J., & Cornish, K. (2016), Developmental Science | 10 |



Business

Cooperative Research
Centres Program

TALi DETECT is developed under the
Cooperative Research Centres Program (CRC-P).

The technology driving TALi® solutions including, but not limited to TALi® DETECT, TALi® TRAIN and TALi® Portal are protected by U.S. Patent No. 10,621,882. Additional patents may be pending in the U.S. and elsewhere.

Study 05

TALi TRAIN

11

Computerised attention training for children with intellectual and developmental disabilities: A randomised controlled trial

Kirk, H., Gray, K., Ellis, K., Taffe, J., & Cornish, K. (2016). *Journal of Child Psychology and Psychiatry*

Study 06

TALi TRAIN

12

Impact of attention training on academic achievement, executive functioning, and behaviour: A randomised controlled trial

Kirk, H., Gray, K., Ellis, K., Taffe, J., & Cornish, K. (2017). *American Journal on Intellectual and Developmental Disabilities*

Study 07

TALi TRAIN

13

Gamified attention training in the primary school classroom: A cluster-randomised controlled trial

Kirk, H., Spencer-Smith, M., Wiley, J., & Cornish, K. (2019). *Journal of Attention Disorders*

Study 08

TALi TRAIN

14

Examining potential predictors of attention training outcomes in children with intellectual and developmental disorders

Kirk, H., Raber, A., Richmond, S., & Cornish, K. (2020). *Journal of Intellectual & Developmental Disability*

Key Terms/Glossary

Attention,

may be the most important skill we have. Attention allows us to concentrate on a task and switch our focus, whilst stopping us from responding impulsively to distractions. Attention has been highlighted as a significant predictor of educational and vocational outcomes. Children with poor attention skills are shown to have fewer social relationships and increased vulnerability for mental health issues, whilst being at a greater risk for substance abuse and incarceration.

The core attention networks are selective attention, sustained attention and attentional control. Selective attention refers to the ability to attend to relevant information whilst simultaneously ignoring irrelevant information. This skill is particularly important in early childhood and helps children to direct attention appropriately at home and within the classroom. Sustained attention refers to the ability to maintain focus over a prolonged period of time. This skill is important to enable children to remain engaged with a task and to listen to instructions. Attentional control refers to the ability to shift attention and to prevent impulsive responding. This skill is more complex than the other attention processes and as such develops later in childhood.

Developmental disorders,

usually have a childhood onset but tend to persist into adulthood, sometimes causing impairment or delay in functions related to the central nervous system maturation. Some people with these disorders display a degree of intellectual disability and many do not. Some people with these disorders display difficulties in adaptive behaviour whilst others do not. Developmental disorders include down syndrome (DS), autism spectrum disorder (ASD), and attention deficit hyperactivity disorder (ADHD).

Down Syndrome (DS),

Trisomy 21, is a chromosomal abnormality, characterised by the presence of a third (partial or total) copy of chromosome 21, with clinical manifestations that may include; variable intellectual ability, muscular hypotonia and joint laxity, facial dysmorphism; variable malformations (essentially heart and digestive) and a risk of complications (epilepsy, leukaemia, auto-immune and endocrine pathologies, earlier aging and Alzheimer's disease).

World Health Organization's (WHO's) International Classification of Diseases – 11_LD40.0

Autism Spectrum Disorder (ASD),

is characterised by persistent difficulties in the ability to initiate and to sustain reciprocal social interaction and social communication, and, by a range of restricted, repetitive, and inflexible patterns of behaviour and interests.

The onset of the disorder occurs during the developmental period, typically in early childhood, but symptoms may not fully manifest until later, when social demands increase.

Deficits are sufficiently severe to cause impairment in personal, family, social, educational, occupational or other important areas of functioning and are usually a pervasive feature of the individual's functioning observable in all settings, although they may vary according to social, educational, or other contexts. Individuals along the spectrum exhibit a full range of intellectual functioning and language abilities.

World Health Organization's (WHO's) International Classification of Diseases – 11_6A02

Attention Deficit Hyperactivity Disorder (ADHD),

is characterised by a persistent pattern (at least 6 months) of inattention and/or hyperactivity-impulsivity. Onset typically occurs during the developmental period from early to mid-childhood. The degree of inattention and hyperactivity-impulsivity is outside the limits of normal variation expected for a child's age and intellectual functioning and additionally, the inattention-hyperactivity significantly interferes with academic, occupational or social functioning.

Inattention refers to: significant difficulty in sustaining attention to tasks that do not provide a high level of stimulation or frequent rewards; distractibility; and problems with organisation. Hyperactivity refers to excessive motor activity and difficulties with remaining still, most evident in structured situations that require behavioural self-control. Impulsivity is a tendency to act in response to immediate stimuli, without deliberation or consideration of the risks and consequences.

World Health Organization's (WHO's) International Classification of Diseases – 11_6A06

TALi DETECT,

is a gamified assessment tool designed to assess the attentional capabilities of millions of children entering the education system annually. The gamified subtests are based on well-established, standardised cognitive assessments that have been modified for use with young children. While TALi DETECT is not a formal diagnostic tool for identifying developmental delays or disorders, it is designed to triage children with early indication of attention vulnerabilities to appropriate early interventions.

TALi TRAIN,

is an evidence-based training program, developed to improve attention and support learning in childhood. Designed by a team of neuroscientists at Monash University, the program is the result of over 20 years of research in developmental psychology and cognitive neuroscience.

See talihealth.com.

Study 01
TALi DETECT

Gamified Assessment of Attention in Early Childhood: A Large-Scale Validation Trial

TALi Health Pty Ltd

Rationale

Deficits in attentional capabilities lead to a range of negative life outcomes including increased risk of lowered educational attainment and mental health issues. Given that, there have been numerous attempts to measure attentional skills in early childhood with the intent of early intervention and diminishing the negative life-long consequences of attention difficulties. These include objective and subjective measures of a range of attentional domains. TALi DETECT is an app that has been designed to objectively assess several key attentional domains in young children. It uses a modern games approach to ensure participation on behalf of each child and consists of 7 literature-based cognitive tasks known to measure Selective Attention, Sustained Attention and Executive Attention.

In this study three important psychometric characteristics of DETECT, as an attention assessment tool, were investigated:

- Validity;
- Reliability; and
- Developmental sensitivity.

Methods

Participants:

340 neurotypical Australian children with IQ Composite scores >70, 4-8 years of age

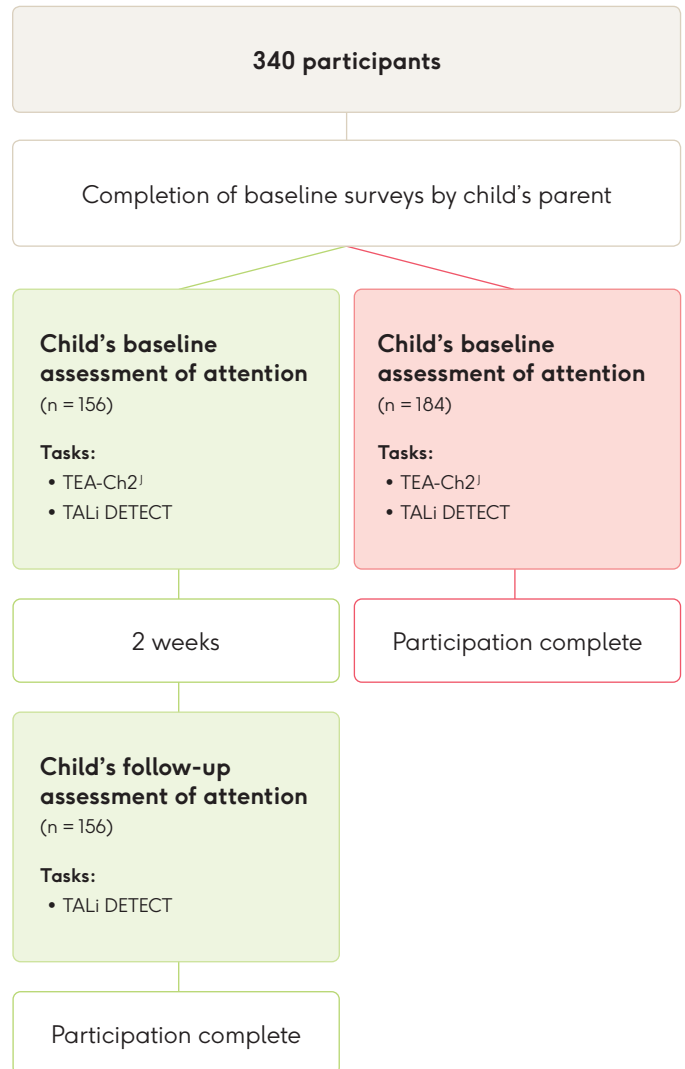
Randomised into:

1. Baseline and follow-up assessments (n=156)
2. Baseline assessment (n=184)

Location:

Schools, kindergarten and childcare centres

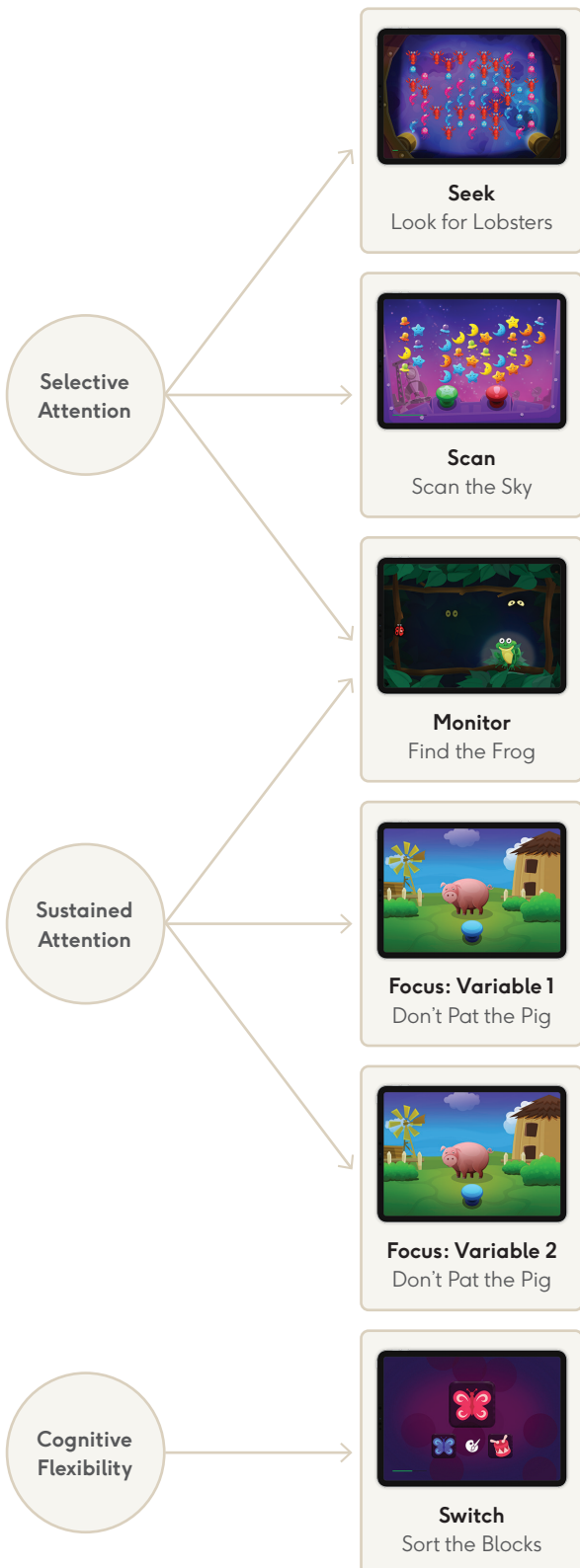
Study design:



Results

Validity:

Using Structural equation modelling (SEM), it was confirmed that DETECT subtests can measure three major domains of attention and there is sufficient differentiation between them:



An established, traditional measure of attentional skills was used to establish convergent validity by calculating correlation with the subtest scores of DETECT. The correlation between all five individual TALi DETECT subtests and the respectively comparable subtests in TEA-Ch2¹*, was in a satisfactory range (~0.3-0.7).

The table below shows that DETECT subtests have adequate correlation with TEA-Ch2¹ subtests:

| DETECT game | TEA-CH2 ¹ game | Strength of correlation | Result |
|-------------|---------------------------------------|-------------------------|--|
| Speed | Simple Reaction Time | | ● In acceptable range |
| Seek | Balloon Hunt | | ● In acceptable range |
| | Balloons 5 | | ● In acceptable range |
| Scan | Hide and Seek Visual | | ● In acceptable range |
| | Balloon Hunt | | ● In acceptable range |
| Monitor | Balloons 5 | | ● In acceptable range |
| | Hide and Seek Visual | | ● In acceptable range |
| Focus | SART | | ● In acceptable range |
| Switch | No equivalent in TEA-Ch2 ¹ | | |

* The TEA-Ch2¹ is an individually administered assessment that measures separable aspects of attention for children ages 5–7.

Reliability:

The psychometric property of reliability was also established. Reliability is defined as the stability of scores obtained by a person when re-examined with the same test multiple times. Stability of test scores across time is important for longitudinal studies.

DETECT's Sustained Attention and Selective Attention indexes showed high test-retest reliability while Cognitive Flexibility showed lower test-retest reliability.

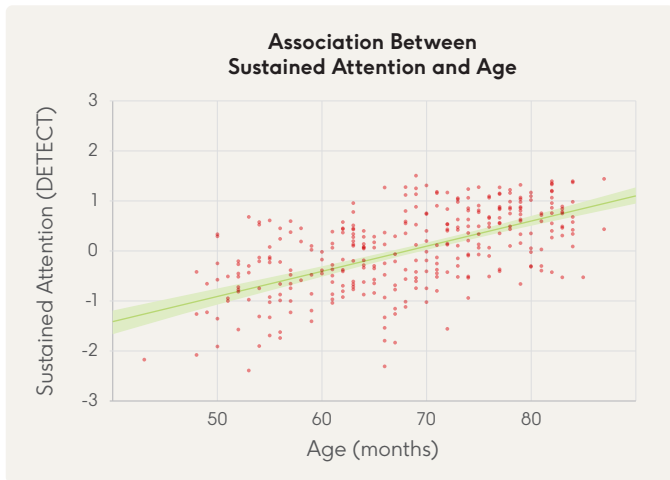
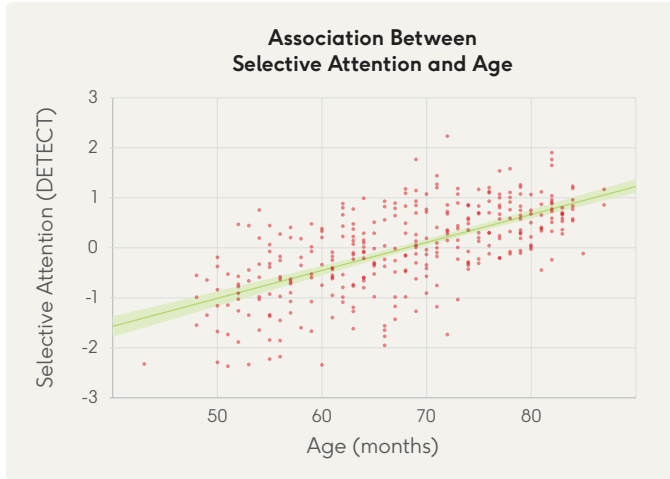
| DETECT Attention Index | Strength of correlation | Result |
|---|-------------------------|---|
| Selective Attention | | ● In acceptable range |
| Sustained Attention | | ● In acceptable range |
| Executive Attention / Cognitive Flexibility | | ● Test-retest reliability is lower than the expected threshold [#] |

[#]The issue of lower reliability of this latent factor will be addressed in future studies by refining the related cognitive tasks and adding additional indicators of this construct.

Developmental Sensitivity:

Associations of test scores with age reflect the validity of the tests for measuring cognitive development during childhood. DETECT has good developmental sensitivity. Age was positively associated with performance on:

- Selective Attention ($\beta = .57, p < .001$);
- Sustained Attention ($\beta = .44, p < .001$); and
- Cognitive Flexibility ($\beta = .23, p < .001$).



Key Finding

TALi DETECT features a comprehensive battery of diverse cognitive assessment tasks delivered in a gamified and engaging format which facilitate estimation of a child's strengths and weaknesses in major domains of attention. It can measure a child's Selective and Sustained Attention with high reliability, and its reliability to estimate a child's Executive Attention skills will be investigated further in future studies.

Significance

The results of this study provide foundational evidence for DETECT as an objective measure of attentional skills in early childhood. The study results position DETECT as a leading tool to facilitate an objective baseline measurement of attention skills in early childhood. DETECT complements existing observation-based assessments of attention and will provide an essential check point. Early detection of attention issues provides opportunity for earlier intervention. This is not only critical to the immediate and long-term wellbeing of a child but also has significant economic benefits to the community.

Study 02

TALi TRAIN

Cognitive training as a resolution for early executive function difficulties in children with intellectual disabilities

Kirk, H., Gray, K., Riby, D., & Cornish, K. (2015), *Research in Developmental Disabilities*

<https://www.sciencedirect.com/science/article/abs/pii/S0891422214005319>

Rationale

This study reviewed existing cognitive training programs that aim to improve cognitive and behavioural functions, and gauged any potential benefits that may be offered to children with intellectual disorders.

Executive Functions: Target Training Domains

Working Memory Training

The majority of cognitive training programs available to children target working memory (WM). Within these programs, improvements in working memory tasks have been found for both typically developing children and those with Attention Deficit Hyperactivity Disorder (ADHD).

Mostly, these improvements were found to occur in the WM tasks that were directly targeted through the training tool (referred to as 'near transfer' effects). For example, improving performance on verbal WM tasks after undergoing training on visuospatial WM tasks. However, some caution should be taken when interpreting near transfer effects, as the assessments used to measure improvements after training often closely resemble the tasks used in the training programs themselves. Hence, the improvement might simply be the result of practice effects rather than changes in broader cognitive skills.

In contrast to near transfer effects, improvements in untrained domains such as ADHD symptoms, attention or IQ (referred to as 'far transfer' effects) were, in many cases, not observed outside of the training tool. This lack of far transfer effects suggests that working memory training may only be reliable in producing changes in targeted domains and highlights the potential limits of this intervention in producing more widespread improvements, such as behaviour or academic achievement.

Attention Training

Cognitive training targeting attention has revealed improvements in attention in children with ADHD as well as improvements in non-trained skills such as mathematical competence and parent reported inattentive behaviour.

Training targeting attention has been more promising for both typically developing children and those with ADHD, though a lack of improvement in inhibitory control is thought to be due to the non-adaptive nature of the tasks. There is promising support for the potential of attention training programs to produce both near and far transfer effects, however, as some studies show that far-transfer effects occur and some do not, it appears universal far-transfer effects for attention training are still elusive.

Gaps in the Efficacy of Cognitive Training for Children with Intellectual Disabilities

Difficulties in cognitive abilities are prevalent in children with intellectual disorders. Despite this, there are currently very few training programs that target children with reduced cognitive capacity. Therefore, the extent to which training-induced improvements may occur in children with severe executive function difficulties is yet to be confirmed. However, the emergence of touch screen tablets offers the potential to engage these children with early intervention.

Conclusion

Cognitive training programs focussing on working memory and attention have shown some promising results in both typically developing children and those with ADHD. However, this review found there was not sufficient evidence to fully evaluate the effectiveness of these interventions.

Between cognitive training paradigms targeting working memory and the ones targeting attention, the latter strategy is preferable in children with intellectual disability due to an already severely reduced working memory capacity. Therefore, developing computer-based cognitive training interventions that target attention is critical for these children.

Study 03
TALi TRAIN

Visual attention and academic performance in children with developmental disabilities and behavioural attention difficulties (part 1)

Kirk, H., Gray, K., Riby, D., Taffe, J., & Cornish, K. (2016), *Developmental Science*
<https://onlinelibrary.wiley.com/doi/abs/10.1111/desc.12468>

Rationale

This study aimed to provide a comprehensive assessment and comparison of the types of attention difficulties experienced by children diagnosed with Down Syndrome (DS), Autism Spectrum Disorder (ASD) and other Non-Specific Intellectual Disability (NSID), who were rated as having similar behavioural attention difficulties.

Methods

Participants:

77 children with developmental disorders (Autism Spectrum Disorder (n=23), Down Syndrome (n=22), Non-Specific Intellectual Disability (n=32)), 4–11 years of age.

Measures:

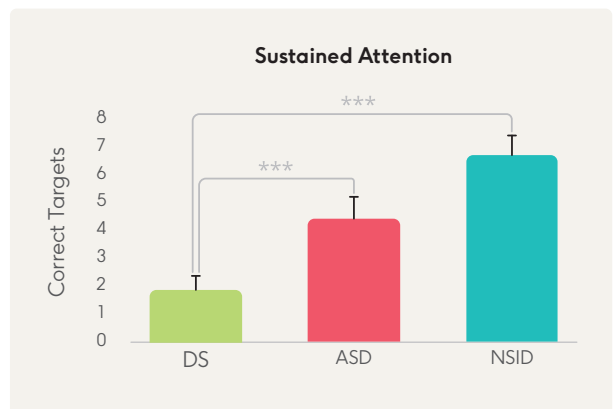
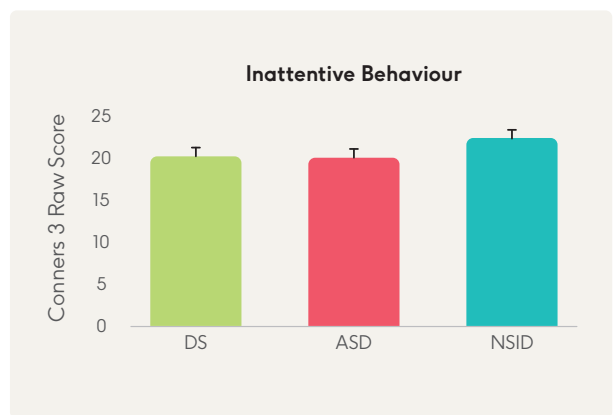
- Computerised cognitive attention battery:
 - Selective attention (Visual Search)
 - Sustained attention (Vigilance)
- Behavioural rating scale of inattention

Key Finding

Despite comparable levels of inattentive behaviour, children with Down Syndrome had poorer visual search (selective attention) and vigilance abilities (sustained attention) than children with Autism Spectrum Disorder or those with Non-Specific Intellectual Difficulties.

Significance

Importantly, this study highlights that commonly used behavioural rating scales are not sensitive enough to detect differences in underlying attention skills. It is important to accurately assess attention difficulties in children with developmental disorders to facilitate the design of tailored interventions that meet the unique needs of each child.



Study 04
TALi TRAIN

Visual attention and academic performance in children with developmental disabilities and behavioural attention deficits (part 2)

Kirk, H., Gray, K., Riby, D., Taffe, J., & Cornish, K. (2016), *Developmental Science*
<https://onlinelibrary.wiley.com/doi/abs/10.1111/desc.12468>

Rationale

This study aimed to assess the relationship between attention difficulties and academic skills such as literacy and numeracy.

Methods

Participants:

77 children with developmental disorders (Autism Spectrum Disorder (n=23), Down Syndrome (n=22), Non-Specific Intellectual Disability (n=32)), 4–11 years of age.

Measures:

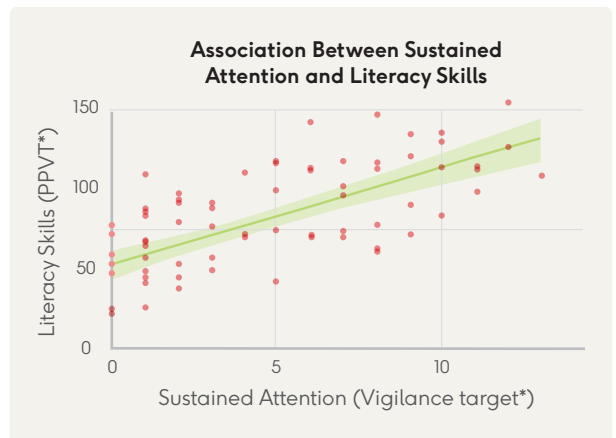
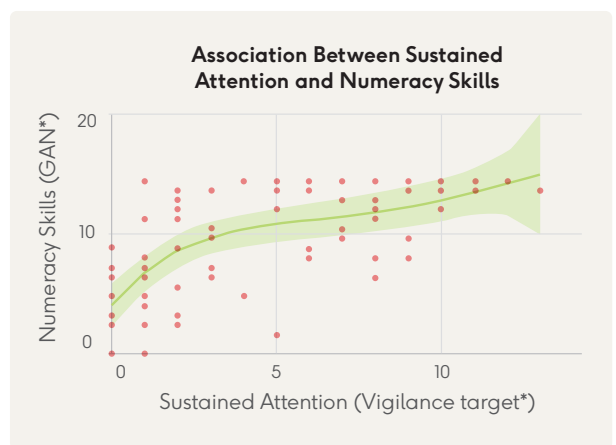
- Sustained attention (Vigilance)
- Early literacy skills: Receptive vocabulary (PPVT)
- Early numeracy skills: Cardinality (GAN)

Key Finding

Visual attention is significantly associated with literacy and numeracy skills, regardless of a child's developmental disorder.

Significance

The association between visual attention and academic skills is a highly useful early indicator of learning impairments, and a potential target for early intervention for children with and without intellectual and developmental disorders.



*GAN: "give-a-number" protocol; a measure of cardinality.

*Vigilance target: A measure of sustained attention in Wilding Attention battery (WATT).

*PPVT: The Peabody Picture Vocabulary Test 4; a measure of receptive vocabulary.

Study 05
TALi TRAIN

Computerised attention training for children with intellectual and developmental disabilities: A randomised controlled trial

Kirk, H., Gray, K., Ellis, K., Taffe, J., & Cornish, K. (2016), *Journal of Child Psychology and Psychiatry*
<https://acamh.onlinelibrary.wiley.com/doi/abs/10.1111/jcpp.12615>

Rationale

This study aimed to assess the immediate and long-term efficacy of a computerised attention training program (TALi TRAIN) on attentional difficulties in children with developmental disorders including Down Syndrome (DS), Autism Spectrum Disorder (ASD), and Non-Specific Intellectual Disability (NSID).

Methods

Participants:

75 children with developmental disorders (ASD, DS, NSID), 4–11 years of age

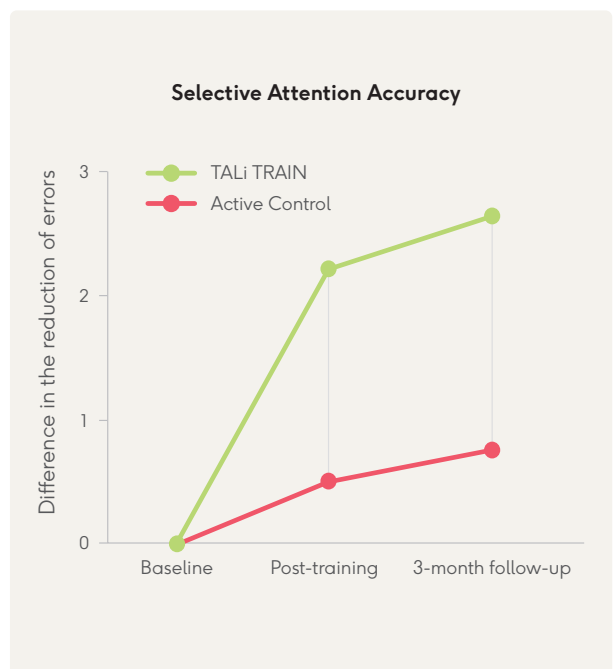
Randomised into:

1. TALi TRAIN (n=38)
2. Control program (n=37): used to control for time spent using a touchscreen program, increased parent involvement and adhering to scheduled training.

Location: home-based

Training duration: 5 weeks

Follow-up: 3 months



Key Finding

Children in the TALi TRAIN group showed a significantly greater reduction in the number of errors made on the selective attention task from baseline to post-training and baseline to 3-month follow-up than children in the control condition.

Significance

The current findings provide evidence that training can positively influence aspects of attention (selective attention) in children with developmental disorders. These findings are important as they highlight that impairments of attention are not necessarily permanent in children with developmental disorders and, by using intensive computerised attention training, they can be improved.

Study 06
TALi TRAIN

Impact of attention training on academic achievement, executive functioning, and behaviour: A randomised controlled trial

Kirk, H., Gray, K., Ellis, K., Taffe, J., & Cornish, K. (2017), *American Journal on Intellectual and Developmental Disabilities*
<https://meridian.allenpress.com/ajidd/article/122/2/97/648/Impact-of-Attention-Training-on-Academic>

Rationale

The aim of this study was to investigate the efficacy of computerised attention training (TALi TRAIN) on untrained outcomes such as executive functions, literacy and numeracy skills, and behavioural/emotional problems in children with developmental disorders.

Methods

Participants:

75 children with developmental disorders (Down Syndrome (DS), Autism Spectrum Disorder (ASD), and Non-Specific Intellectual Disability (NSID)) from 4–11 years of age.

Randomised into:

1. TALi TRAIN (n=38)
2. Control program (n=37)

Location: home-based

Training duration: 5 weeks

Follow-up: 3 months

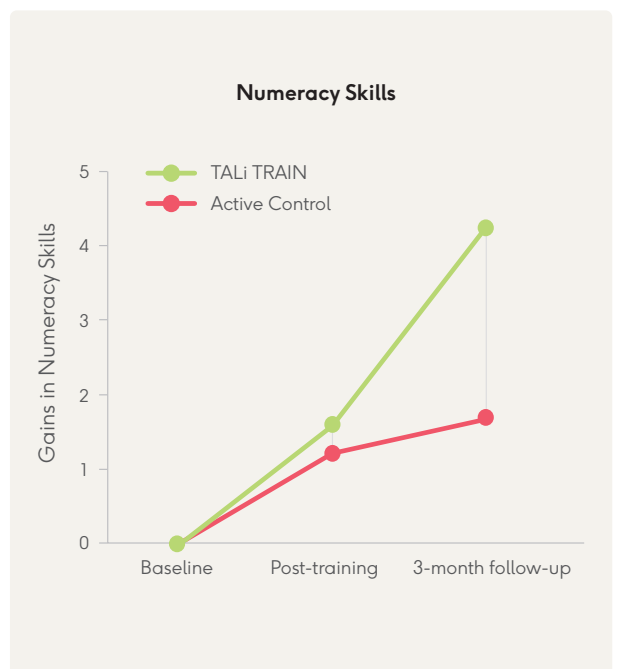
Key Finding

Children in the training group showed significantly greater improvements in numeracy skills at the 3-month follow-up, compared with children in the control program.

Significance

Improvements in untrained skills are very rare. These findings provide evidence that certain untrained skills in children with developmental disorders, such as numeracy, can be modestly improved, using intensive computerised attention training.

TALi TRAIN is one of the very few programs to show an untrained improvement in learning. This is important as attention training may have the potential to overcome some of the academic difficulties faced by individuals with developmental disorders and support children’s educational development.



Study 07
TALi TRAIN

Gamified attention training in the primary school classroom: A cluster-randomised controlled trial

Kirk, H., Spencer-Smith, M., Wiley, J., & Cornish, K. (2019), *Journal of Attention Disorders*
<https://journals.sagepub.com/doi/abs/10.1177/1087054719887435?journalCode=jada&>

Rationale

This study aimed to assess the immediate and long-term effects of gamified attention training (TALi TRAIN) on attention difficulties in primary school children in classroom setting.

Methods

Participants:

98 children (IQ Composite scores >70) from 8 classes, 5-9 years of age.

Randomised into:

1. TALi TRAIN (n=38)
2. Placebo control (n=31): used to control for time spent using a touchscreen program, increased parent involvement and adhering to scheduled training
3. No-contact control (n=29): usual classroom teaching and did not use any form of cognitive training program

Location: school-based

Training duration: 5 weeks

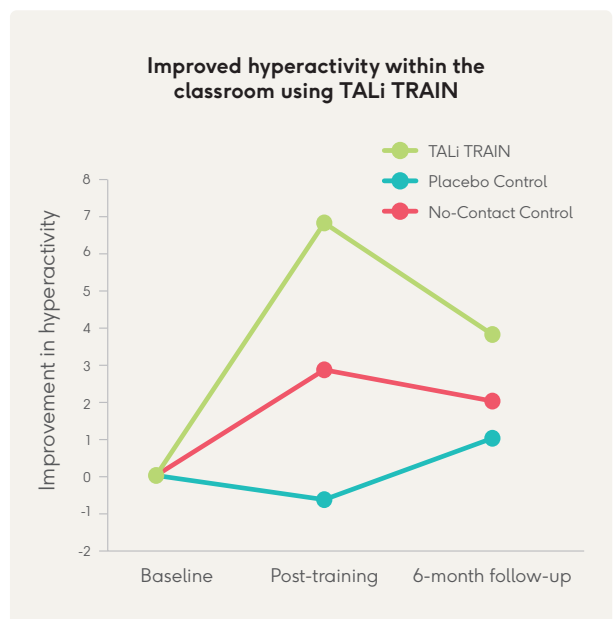
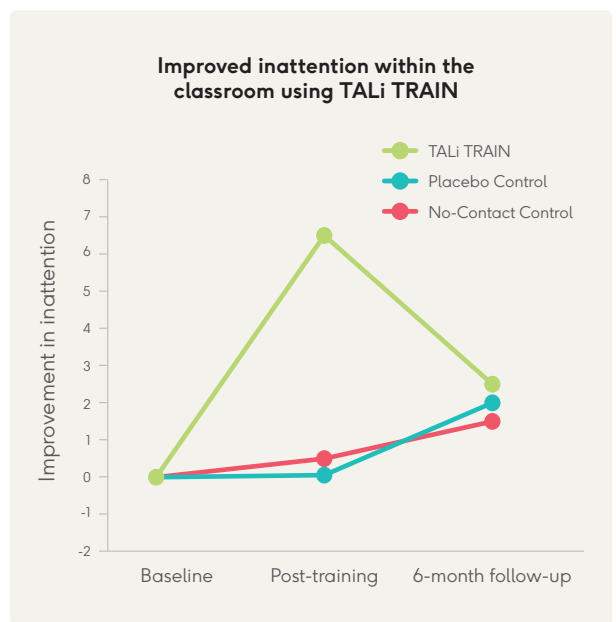
Follow-up: 6 months

Key Finding

Use of TALi TRAIN as an attention training intervention promoted greater reductions in inattentive and hyperactive behaviours in the classroom compared with both control conditions.

Significance

These findings provide evidence that classroom-based attention training has some benefits in reducing inattentive and hyperactive behaviour in classroom environment, and benefits can persist in the long-term (6 months), although with smaller effect magnitude.



Study 08
TALi TRAIN

Examining potential predictors of attention training outcomes in children with intellectual and developmental disorders

Kirk, H., Raber, A., Richmond, S., & Cornish, K. (2020), *Journal of Intellectual & Developmental Disability*
<https://www.tandfonline.com/doi/abs/10.3109/13668250.2020.1821939>

Rationale

Our previous research has shown that TALi TRAIN helps improve selective attention accuracy in children with intellectual and developmental disorders at a group level. But responses to digital cognitive training interventions vary greatly among different individuals. Investigating possible predictors of cognitive training-induced improvements is vital in ascertaining which individuals benefit the most from these interventions.

Methods

Participants:

73 children with intellectual and developmental disorders (4–11 years of age) randomised into TALi TRAIN or a control program.*

* Used to control for time spent using a touchscreen program, increased parent involvement and adhering to scheduled training.

Location: home-based

Training duration: 5 weeks

Measures:

The children's baseline autistic symptomatology, adaptive functioning and attention abilities were investigated as potential predictors of improvements in selective attention after completing TALi TRAIN.

Key Finding

Children with lower adaptive functioning (i.e., social, conceptual and practical skills) and better baseline selective attention skills experienced greater gains in their visual search ability after completing TALi TRAIN intervention (compared to active control).



Significance

Among children with intellectual and developmental disorders, attention training using TALi TRAIN may be most beneficial for those who have lower social, conceptual and practical skills, and for those who commenced TRAIN at a better baseline standard. Due to the small sample size, though, these results should be interpreted with caution.



TALI®

Our Mission

To help the littlest humans* find their happy.

*We know all children thrive with better attention. We want to support them early to give them a better chance at improving their attention, and finding that happy.

ARTG: 303352 | FDA Medical Device Class 2, Regulation No. 882.1470 FEI: 3014642289