Institution: Kingston University

Unit of Assessment: 4, Psychology, Psychiatry and Neuroscience

Title of case study: Improving number learning in preschool children through delivery of the "PLUS" learning scheme

1. Summary of the impact (indicative maximum 100 words)

Research at Kingston University led to the development of a preschool number learning scheme ("PLUS") which uses short matching and estimation games to improve the number abilities of preschool children. The programme was first delivered by trained postgraduate students to 60 children at five regional nursery schools. An evaluation study confirmed the efficacy of the programme in enhancing the children's numerical (and other) skills. Next, Dr Van Herwegen trained staff members in these five preschools and five others to deliver PLUS on a daily basis, to reach over 500 pre-schoolers across the region. This resulted in a change to institutional practices within these preschools.

2. Underpinning research (indicative maximum 500 words)

In 2010, Dr Van Herwegen was appointed as Lecturer at Kingston University. The following year, 2011-12, she collaborated with with Prof Karmiloff-Smith (Institute of Child Health) on a study of infants with Down Syndrome (mental age = 6-38 months) to show that the infants' abilities to discriminate between large numerosities or their approximate number system (ANS) abilities were predictive of their later number abilities. This work resulted in a research paper in *Proceedings of the National Academy of Sciences* published in late 2012. In 2013, her work on ANS abilities in young children (before and since joining Kingston University) also formed the basis of a book chapter written by Dr Van Herwegen. Dr Van Herwegen was responsible for devising and developing the test paradigm that underpins this work and which is described in the *PNAS* paper.

The programme of research also investigated specifically why children with Down Syndrome and Williams Syndrome had problems with the ANS system. Evidence from eye movements had suggested that problems with the planning of saccades might contribute to ANS problems in atypical populations.

However, typically-developing children have no problems planning saccades, so it was reasoned that intervention studies can be targeted directly to ANS abilities (and eye movements ignored) to improve the number abilities of typically developing children.

Given that Dr Van Herwegen has devised tasks that assess ANS abilities at different ages, and her work demonstrates that ANS performance at infancy is predictive of later numeric abilities, it was concluded that intervention to improve ANS abilities in preschool children might have measurable benefits later. This led to the development of the "PLUS" preschool number learning scheme.

3. References to the research (indicative maximum of six references)

Karmiloff-Smith, A., D'Souza, D., Dekker, T., **Van Herwegen, J.**, XU, F., Rodic, M., & Ansari, D. (2012). Genetic and environmental vulnerabilities in children with neurodevelopmental disorders. *PNAS*, 109 (2), 17261–17265. DOI:10.1073/pnas.1121087109 [Journal Impact Factor 9.737, 4 citations]

Van Herwegen, J. & Karmiloff-Smith, A (2013). Genetic developmental disorders and numerical competence across the lifespan. In: R. Cohen Kadosh & A. Dowker (Eds.), *Oxford Handbook of Numerical Cognition*. Oxford: Oxford University Press.

4. Details of the impact (indicative maximum 750 words)

The impact comprises institutional changes in the delivery of play activities (the "PLUS" programme) specifically intended to support and develop numerical skill acquisition in preschool children. An evaluation study confirmed the efficacy of the programme, which has now been rolled out to preschools in Kingston, Surbiton, New Malden and Wimbledon. The preschools have confirmed that they will continue to deliver the programme as part of their regular activities.

By adopting the "PLUS" programme (devised by Kingston University academics, with training delivered by staff and postgraduate students from the university), the institutions have improved the numerical skills of their children, evidenced by an intervention study conducted by KU. The intervention was a controlled study designed to evaluate changes in number abilities following implementation of the PLUS programme on a daily basis for five weeks. From December 2012 to April 2013, five trained postgraduate students from the MSc Child Psychology programme and two research assistants visited 5 local nurseries. During these one-hour visits the students played PLUS games devised to improve the children's ANS abilities, comparing pairs of children in an intervention group receiving the PLUS activities, and a control group (who read books with the researcher instead), matched on IQ scores. Before and after the intervention study, children's number and reading abilities were measured using standardised tests. The results confirmed that children in the intervention group performed significantly better on tasks that involved their approximate number system (ANS) post-intervention (mean= 38.3; SD= 10.8) compared to pre-intervention (mean= 42.1, SD= 11.6); $t(17)= -3.03$, $p = .008$. In addition, there was a significant improvement in their counting abilities $t(17)= -3.74$, $p = .002$ (average counting pre-intervention was 18.4 digits, SD= 21.6; post-intervention mean was 22.8, SD= 20.2) as well as visuospatial working memory abilities; $t(8)= -2.79$, p= 0.023 (mean pre-intervention score: 3.3, SD= 2.5; post-intervention score mean = 5.6, SD= 2.2). In contrast, for the control reading group there was only a near-significant improvement for verbal working memory (p= 0.054), not for counting or ANS abilities (all p's > 0.05). The intervention study clearly showed that PLUS improved the preschoolers' number abilities (full data/outcomes report available on request).

From April to June 2013, staff at 5 additional preschool settings were trained to administer PLUS on a daily basis to all of their preschool children. Evidence from managers (see attached) is available to confirm that PLUS has been incorporated into their daily provision. On the basis of the programme's success, the Operations Manager for a number of preschools (*Dicky Birds Nurseries Ltd.*) has promoted the PLUS scheme with its regional nurseries, leading to adoptions of the programme in Surbiton (Claremont Hall Nursery and 62 Claremont Road Nursery), Wimbledon (Dundonald Road Nursery and Queens Road Nursery) and New Malden (New Malden Nursery). Other adoptions include in Tolworth (Surbiton Advantage Nursery and the Playtime Nursery), Norbiton (Coombe Day Nursery) and Kingston (Dolphin Nursery and Preschool).

Questionnaires were distributed to nursery managers and staff to evaluate their views on the learning scheme. The 79 responses show that the intervention and training has raised awareness amongst staff in terms of how number abilities in children might be developed, and how the types

of number games local nurseries incorporate in their daily care provision have benefited from PLUS. Letters from preschool managers demonstrate high levels of satisfaction with the programme and a willingness to continue with it; they also demonstrate that the preschools intend to maintain a relationship with KU in order to benefit from research-led initiatives in future.

5. Sources to corroborate the impact (indicative maximum of 10 references)

Results from the questionnaire distributed to service users are available to demonstrate institutional changes in awareness and practice.

Letters from nursery school managers have been obtained confirming the impacts made by Kingston University in terms of the benefits of the PLUS scheme, its incorporation into daily activities provision and the use of research to inform practices long-term:

1. Manager, Dicky Birds Nursery, Surbiton
2. Manager, Play Time Nursery, Tolworth
3. Manager, Coombeday Nursery, Norbiton

Corroboration of the promotion of the PLUS scheme to regional nurseries can be obtained from:

4. Operations Manager, Dicky Birds Nurseries Ltd.