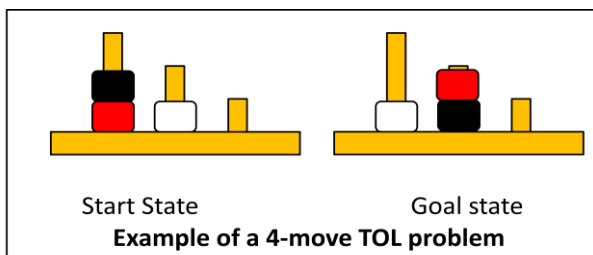## *Summary of PhD Research: Joanne S. Camp*
The development of problem-solving abilities in typical and atypical development.

I began my programme of PhD study in 2010, under the supervision of Professors Emily Farran, Michael Thomas and Annette Karmiloff-Smith. I am very grateful for being able to visit the school to conduct research as part of my studies, and to all the children and parents who made the research possible by taking part. I have now completed writing my thesis and passed the examination process, and am writing up the results for publication in academic journals. This is a summary of the findings which are most relevant for the typically developing participants.

Problem solving is a skill that we use constantly in everyday life, whether we are completing a jigsaw puzzle or looking for a new place to live. It depends on skills known as executive functions, including the ability to plan ahead, keep items active in short-term memory (working memory), switch attention flexibly (shifting), and hold back responses before they are made / maintain focus (inhibition). In this programme of research we aimed to find out more about how children's problem solving changes with age, and how executive functions are used for problem solving on a puzzle-type task, as well as for everyday problems, like finding a lost possession. We investigated this for typically developing children (including visits to the school), and compared their results with those for individuals with two neurodevelopmental disorders: Down syndrome and Williams syndrome.
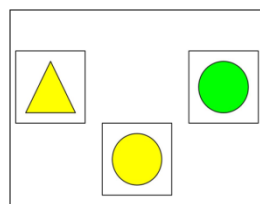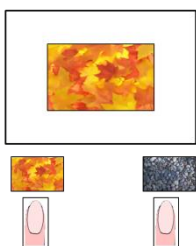
In the typically developing group, 56 children (aged 4-11 years) completed a range of tasks assessing different executive functions and the Tower of London problem-solving task. Thirty-four parents completed a Problem-Solving Questionnaire (PSQ) and the BRIEF (Behavioural Rating Inventory of Executive Function) to provide information about everyday executive functioning and problem solving. We also collected data with individuals with Down syndrome or Williams syndrome and their parents. The tasks we used are illustrated below.
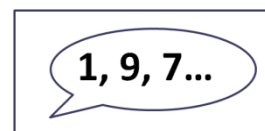
Problem-solving task (Tower of London; TOL)

Start State   Goal state
Example of a 4-move TOL problem

Planning: van loading in reverse

Inhibition: press same, then opposite

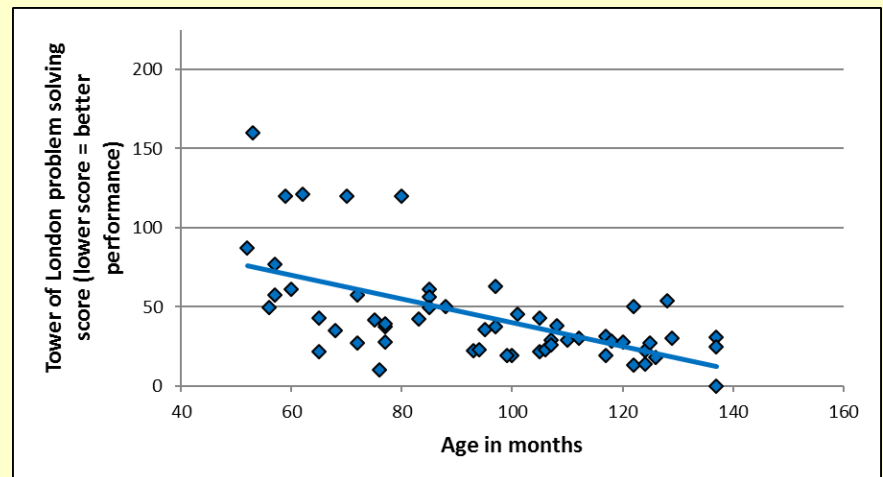Shifting: sort by different criteria (e.g., shape, colour)

1, 9, 7…

Working memory: remembering a sequence of taps on the blocks (visuospatial), and a sequence of spoken numbers (verbal)

Results and Conclusions
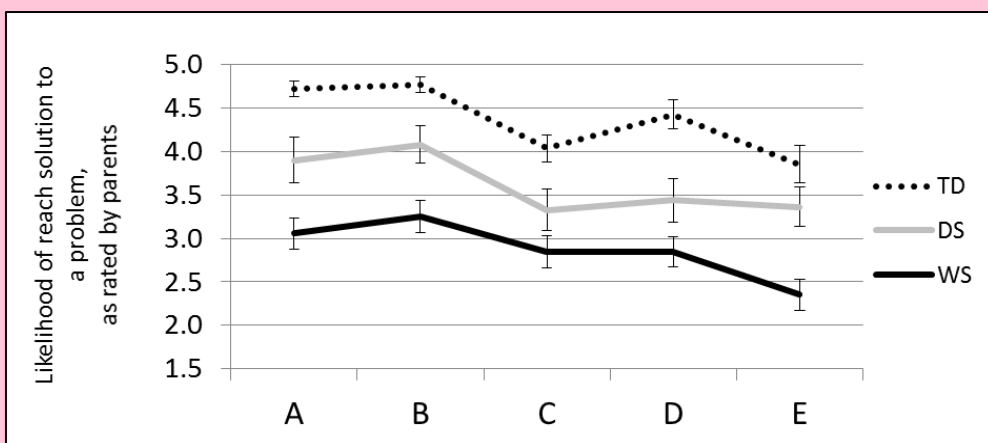
Improvements with age

In line with expectations, problem-solving ability (and executive functioning performance) improved with age for our typically developing sample. That is, children who were older when we ran the study solved the Tower of London (TOL) problems more quickly and were more likely to be correct, while younger children showed more signs of deliberation about the ways the problem could be solved (such as moving a piece to one position and then moving it back again). The Williams and Down syndrome groups' Tower of London performance did not reliably improve with age.

This scatterplot shows the relationship between problem-solving ability and age in the typically developing children.

Routine or novel?

Questionnaire results suggest that solving a problem with a more predictable, routine task (like brushing teeth) was easier than solving a problem with a more novel task (like finding something that is lost). In the graph below, A and B are the routine problems (getting dressed and brushing teeth) while C, D and E are the more novel problems (Finding a lost possession, Packing a bag for the day and Putting items away in a wardrobe / chest of drawers). Higher scores indicate parent ratings as more likely to reach the solution. TD = typically developing children.

Real-life executive functioning and problem solving

Unlike the Down syndrome and Williams syndrome groups, only one aspect of executive functioning on the BRIEF questionnaire (the 'Inhibit' scale) was associated with a higher likelihood of reaching the solution to everyday problems. This could mean that becoming distracted is an important reason why children might struggle with everyday problem solving.

Experimental versus real-life measurement

Problem solving on the TOL was not reliably related to ratings of problem solving in everyday life, for any of the groups. We think this means that real-life problem solving should be considered separately from performance in experimental settings. This is important for researchers to consider when designing future research.

Atypical and typical development

Making comparisons to the typically developing group has also allowed us to draw some interesting conclusions about some different ways in which individuals with Down syndrome and Williams syndrome approach problem-solving tasks. For example, we think that keeping possessions well-ordered could be a strategy that individuals with Down syndrome might use to help them cope with difficulties with everyday problem solving.