

Children's Difficulties Innovating Tools: A Mental Flexibility Problem?

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Introduction

Despite being proficient tool users, and tool makers after instruction, young children display surprising difficulty in innovating tools (manufacturing a novel tool to solve a problem) (Beck, Apperly, Chappell, Guthrie & Cutting, 2011).

The present studies extended this finding to a new task and explored whether 4- to 7- year olds' tool innovation difficulty could be a consequence of mental inflexibility.

3 explanations for tool innovation difficulty were explored:

1. Children find it difficult to move on from unsuccessful ideas and so become "stuck in set".
2. Children are capable of innovating tools but are prevented from doing this due to task pragmatics or permission issues
3. Tool innovation is an intrinsically difficult "ill-structured" problem

The Tasks

Children were presented with the apparatus below (counterbalanced). They were told 'if you can get the sticker out, you can keep it, here are some things that can help you'. Children were then given the displayed materials.



Hooks Task

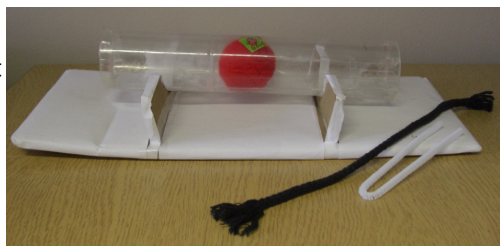
Aim: Retrieve bucket from tube to get sticker.

Solution:
Bend pipecleaner into a hook.

Unbending Task

Aim: Push ball out of tube to get sticker.

Solution:
Unbend pipe-cleaner to make it long enough.



Experiment 1

Investigated the role of switching in the 2 tool innovation tasks which required 'opposite' solutions. This tested the idea that 4- to 5- year old (N = 24) and 6-to7-year old (N = 27) children may become "stuck in set".

Results

Age Group (Years)	N	Success	
		Before Demonstration	Only after Demonstration
Hooks			
4 to 5	24	2 (8%)	19 (79%)
6 to 7	27	8 (30%)	18 (67%)
Unbending			
4 to 5	24	8 (33%)	14 (58%)
6 to 7	27	15 (56%)	11 (41%)

- Hooks results comparable with previous findings.
- Although easier to achieve (McNemar, $p=.011$), success rates for the unbending task are low.
- No effect of task order (Fisher's Exact Tests: Hooks, $p > .999$; Unbending, $p = .781$).
- Children did not persevere on successful techniques across tasks.
- Children displayed low levels of perseverance within tasks
- Children easily succeeded after a demonstration of the relevant action.

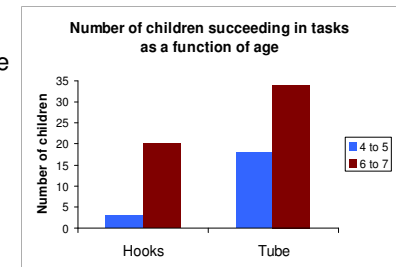
Experiment 2

Minimized the likelihood of permission or pragmatics playing a role in children's poor performance on the tool-innovation tasks by telling children they needed to make something with the materials.

- Significant improvement with age for both tool innovation tasks (Chi-square tests: Hooks, $p < .001$, Unbending, $p = .004$).

- However, the instruction to make something did not aid children in tool innovation.

Results



- Task pragmatics and permission are unlikely to be adequate explanations for children's low success rates.

Age Group (Years)	Unsuccessful			Successful		
	Perseveration			Entry into Tube		
	N	No	Yes	N	Immediate tool	1 unsuccessful then tool
Hooks						
4 to 5	41	17	24	3	2	1
6 to 7	28	24	4	20	7	8
Unbending						
4 to 5	26	19	7	18	10	1
6 to 7	14	13	1	34	20	8

- Younger children perseverated within task more than older children ($p < .001$).

- Successful children succeeded immediately or after just one incorrect insertion

Discussion

- Results support findings of Beck et al. (2011), and extend to a new tool innovation task.
- Experiment 1 suggests that children's tool innovation difficulties may not derive from difficulty with switching between alternative Solutions.
- Experiment 2 suggests that tool innovation difficulties cannot be explained by task pragmatics or permission issues.

- We suggest an alternative hypothesis that tool innovation makes demands on higher level executive function and is an intrinsically difficult "ill-structured" problem (Burgess et al., 1996; Goel, 1995).
- The defining feature of "ill-structured" executive tasks is the requirement to generate a solution that is not directly supplied.

References:

Beck, S.R., Apperly, I.A., Chappell, J., Guthrie, C., & Cutting, N. (2011). Making tools isn't child's play. *Cognition*, 119, 301-306; Burgess, P. W., Alderman, N., Emslie, H., Evans, J. J., Wilson, B. A., and Shallice, T. (1996). The simplified six element test. In Wilson, B. A., Alderman, N., Burgess, P. W., Emslie, H., & Evans, J. J. (Eds.) *Behavioural Assessment of the Dysexecutive Syndrome*. Bury St. Edmunds, UK: Thames Valley Test; Goel, V. (1995). *Sketches of thought*. MIT Press; Cambridge, MA.
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