What Predicts Education Relevant (Implicit) Task-Switching Flexibility?

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Overview

Cognitive flexibility is the ability to modify representations or plans based on changing information in the environment.

Cognitive flexibility is usually measured using explicit task-switching cues. However, in learning environments like classrooms, task-switching cues are often implicit or implied.

We tested children ages 4-6 in computerized variants of a binary rule-switch task. *Task-explicit cue* conditions stated the exact rule on each trial. *Task-implicit cue* conditions only indicated whether to switch or stay on task.

Several other questions were addressed:

❖ Does stimulus matching speed, a low-level factor, predict flexibility? Does practicing low-level matching improve flexibility?

❖ Does task-switching improve with practice? Facilitation from one task-switching test to another, a week later, was tested.

❖ Do inhibition and processing speed predict task-switching flexibility?

Background: Cognitive Flexibility

There are large age group (4-6) and individual differences in cognitive flexibility.

❖ Differences predict early reading and math skills (Bull & Scerif, 2001; Carwright 2008).

❖ Cognitive flexibility is often assumed to be a product of separate cognitive functions:

a) Inhibition of prepotent responses (Diamond et al, 2005)

b) Processing Speed (Cepeda et. al, 2001)

❖ Differences might be due to speed of using cues to select appropriate responses from working memory (Logan and Schneider, 2003)

a) Perseverative children respond slower to a single rule (Cepeda and Munakata, 2007).

b) Arbitrary rules are harder to access in working memory (Chevalier and Blaye, 2009)

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Methods

❖ *Participants: N = 110*

4-year-olds (*n* = 38, mean age = 53.4 months, 19 girls)
5-year-olds (*n* = 38, mean age = 64.4 months, 14 girls)
6-year-olds (*n* = 31, mean age = 78.9 months, 15 girls)

Procedures:

❖ *Screening Tests:* PPVT III-A, Digit Span

❖ *Tests of General Cognitive Functions*

a) Inhibition: Go-No-Go tests; Luria Tapping-test

b) Processing speed: Box Completion (W-J); Button-press (to targets at varying times)

❖ *Unidimensional Matching* [SEE FIGURES]

a) Speed to match color-only or shape-only stimulus after an implicit or explicit cue

b) Cues and stimulus values were same as in Task-Switching tests

❖ *Task-Switching* [SEE FIGURES]

a) Tasks: Match by color or shape.

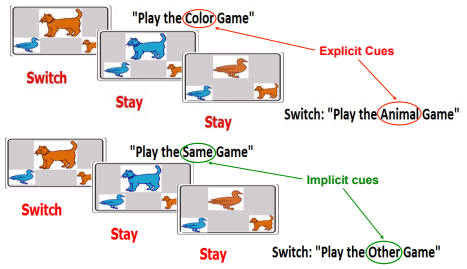
b) Explicit cues: "Play the [Color/Animal] game"

c) Implicit cues: "Play the [Same/Other] game"

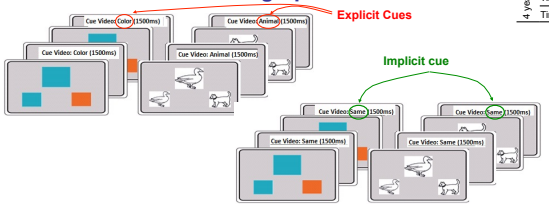
d) Two stimulus sets: Test A (brown/blue cat/duck) and Test B (green/grey pig/bear)

❖ The other switching and matching tests (set A or B) were given one week later

Flexibility: Task-Switching Test



Unidimensional Matching Speed



Results: Task-Switching

❖ Switching: Switch trials slower than stay trials (F = 24.0, p < .001, η^2=.20)

a) Cue x Switch x Congruency interaction:

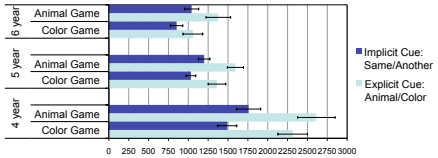
- When Cue is Explicit ("Animal/Color"): Switch costs only on conflict (incongruent) trials
- When Cue is Implicit ("Same/Other"): Switch costs only on non-conflict (congruent) trials

❖ Cues: Responses to *Task-implicit* cues were slower than *Task-explicit* cues (F = 78.7, p < .001, η^2 = .45).

❖ Practice: Responses were faster to second test one week later (F = 4.8, p < .03, η^2 = .05).

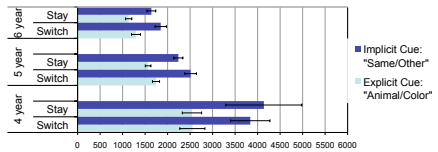
❖ Congruency: No-conflict stimuli faster than conflict (incongruent) (F = 40.1, p < .001, η^2 = .29)

Unidimensional Matching Speed

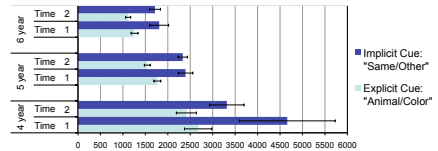


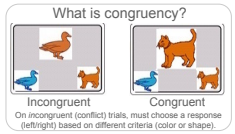
Task-Switch Latency

Switch Effects



Learning Effects





Results: Predictors

❖ Unidimensional Matching Speed

a) *Explicit cues* faster than *Implicit cues* (F = 78.7, p < .001, η^2=.45).

b) Color task trials faster than animal task trials, regardless of cue (F = 78.71, p < .001, η^2 = .45).

❖ With age partialled out, switch costs predicted by unidimensional match speed:

a) Unidimensional speed with *either* implicit or explicit cues predicted significant unique variance.

- Task-Switch w/ Explicit Cues: Predictors are…
  1. Unidimensional Speed w/ Explicit cues: β = .362, R^2 = 0.24 (p < 0.001);
  2. Unidimensional Speed w/ Implicit cues: β = .508, R^2 change = 0.10, p < 0.001
  3. Processing speed: R^2 change = 0.06, p <.001
- Task-switching w/ Implicit cues: Predictor is…
  1. Unidimensional Speed w/ Explicit Cues: β = .51, R^2 change = .10, p < .001

b) Inhibition does not predict significant additional unique variance

❖ Unidimensional speed (Explicit Cue) predicted learning (i.e., faster switching one week later).

a) β = -.842, R^2 change = 0.17, p < 0.001, with *Task-explicit cues*

b) No other test predicted repeat performance in task-switching with *Task-implicit* cues (little improvement)

Conclusions

❖ Cognitive flexibility depends on how well children understand and use cues.

a) Educational relevance: Higher-order or implicit cues are harder

b) Cue effect more pronounced than switch effects when both stimuli and cue are difficult (switch not > stay in conflict conditions with implicit cue)

c) Even with no-conflict stimuli and no switching demands, faster to follow explicit than implicit cues

❖ Efficient switching was predicted by how quickly children could match simple stimuli (i.e., activate a low-level response)

a) General processing speed, but not inhibitory speed, predicted additional variance.

❖ Improved flexibility in a second task-switch test, one week later, was predicted by low-level (unidimensional) stimulus matching.

a) Correlation was strongest in condition with greatest improvement (i.e., task-explicit cue condition)