



How Old Are You?: Towards Identifying Measurable Cognitive Phenomena for Online Age Verification

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This Talk = (Evidence-based) **Theory**
Not (Our) **Experimental Results**



The Problem



- Violent content
- Sexual content
- Gambling
- Social networks

The Problem



- Children chat rooms
- Children gaming platforms
- Children meeting sites

What are currently we doing about it?

Status Quo

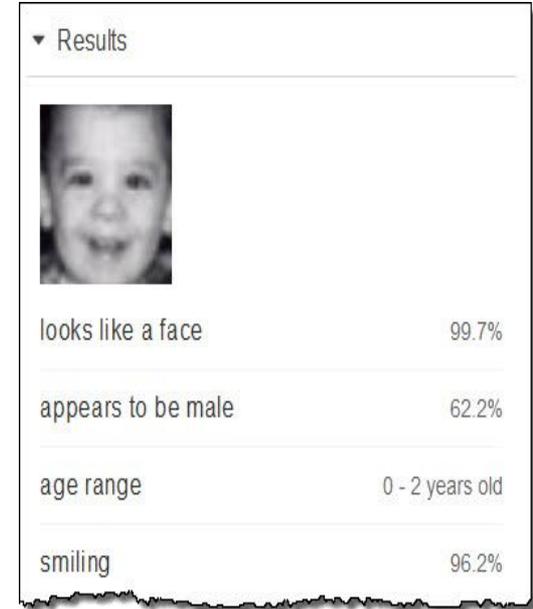
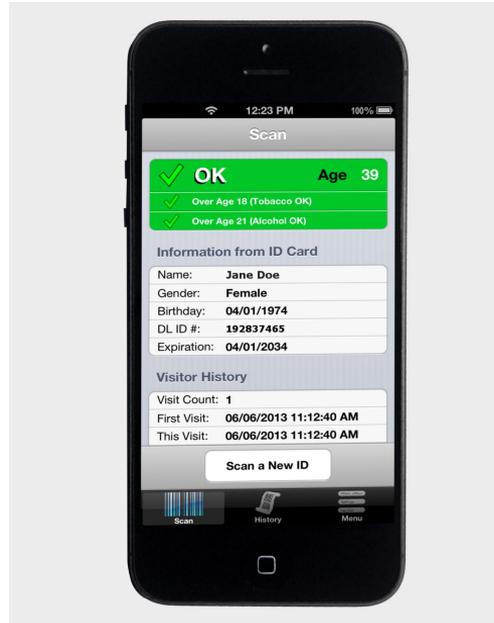
You must be 21 years old to visit this site.

Please verify your age

January - 01 - 2012

Remember me

Other (Research and Deployed) Attempts



What do we need for age verification systems?

(Aside from accurate age verification)

Resistant to spoofing



Logistically feasible

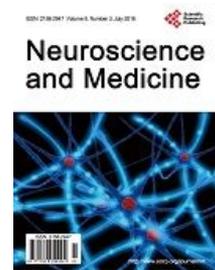
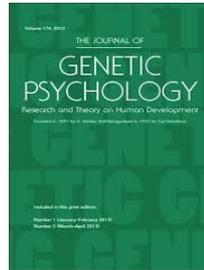
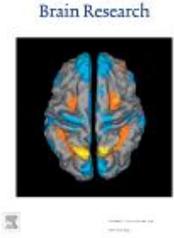
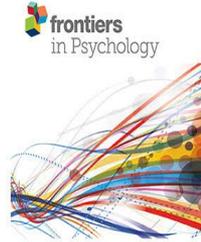


Privacy-respecting



Where can we get inspiration for new
system ideas?

Other Disciplines!



Candidate Tests Where Participants Have Demonstrated Stratified Performance Based on Age

- Interference
 - **Stroop Test**

- Multisensory responses
 - **Choice Tasks**

- Working memory
 - **Digit Span**

How it Works: The Stroop Test

RED BLUE GREEN YELLOW RED

RED BLUE GREEN YELLOW RED

RED BLUE GREEN YELLOW RED

Age Performance for Stroop

Age (years)	4	5	6	7	8	9	10	11	12	13	adult
Stroop C, Computer, Congruent Only, Per Item (ms) [34]	-	-	-	-	-	613 (15.92)					582.4 (11.81)
Stroop C, Computer, Incongruent Only, Per Item (ms) [34]	-	-	-	-	-	814.36 (22.8)					711 (16.91)
Stroop A, Paper, Per 100 Items (secs) [22]	-	-	-	89.8	77.6	68.5	62.3	55.6	59.3	54.1	40.5
Stroop B, Paper, Per 100 Items (secs) [22]	-	-	-	126.9	108.3	100.9	92.8	82.1	86.4	79.5	56.1
Stroop C, Paper, Incongruent Only, Per 100 Items (secs) [22]	-	-	-	264.7	208.3	191.4	184.3	160.8	157.9	147.6	103

The results from publications show that **older participants** perform **more quickly** on average than younger participants, particularly on the incongruent task.

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Stroop C, Computer, Congruent Only, Per Item (ms) [34]	-	-	-	-	-	-	613 (15.92)			-	582.4 (11.81)
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Stroop A, Paper, Per 100 Items (secs) [22]	-	-	-	89.8	77.6	68.5	62.3	55.6	59.3	54.1	40.5
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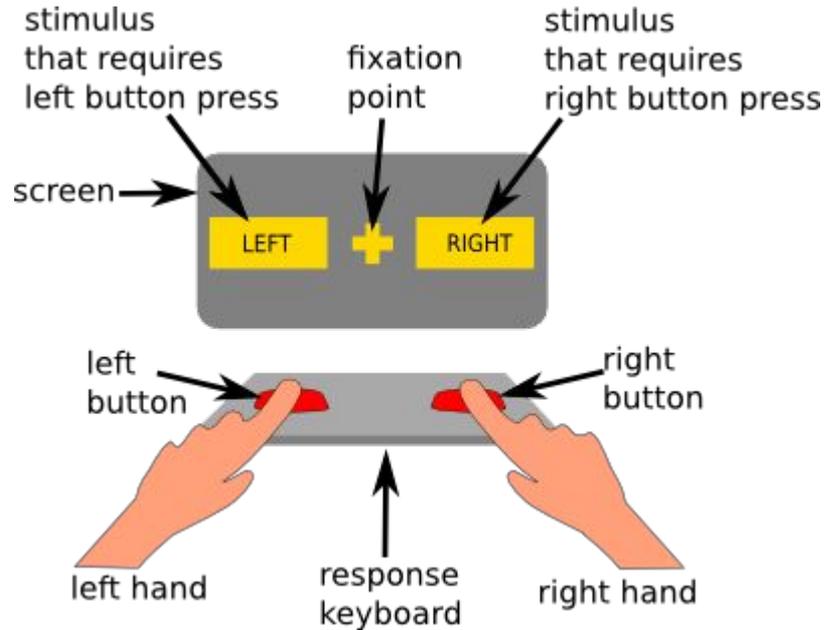


The results from publications show that older participants perform on average faster than younger participants.

Older participants perform more quickly on average than younger participants on the incongruent task.

Children **cannot** perform well enough to spoof adults! (in theory)

How it Works: Multisensory Response Tests



Age Performance for Discrimination Tasks (Multisensory Responses)

Age (years)	4	5	6	7	8	9	10	11	12	13	adult
Simple RT Task (ms) [12]	740 (162)	580 (144)	467 (85)	-	-	-	-	-	-	-	270 (31)
Discrimination RT Task (ms) [12]	1790 (581)	1198 (254)	949 (139)	-	-	-	-	-	-	-	449 (51)
Choice RT Task (ms) [12]	2485 (783)	1652 (437)	1346 (319)	-	-	-	-	-	-	-	704 (132)
Simple RT Task, Audio Only (ms) [6]	-	-	-	~400			~350			~320	~300

The results from these publications show that **older participants** perform **more quickly** on average than younger participants on Simple RT tasks, Discrimination RT tasks, and Choice RT tasks (most particularly on Choice RT tasks). Furthermore, children exhibit a larger difference between their response to auditory and visual stimuli than adults.

Age Performance for Discrimination Tasks (Multisensory Responses)

Age (years)	4
Simple RT Task (ms) [12]	7
Discrimination RT Task (ms) [12]	1
Choice RT Task (ms) [12]	2
Simple RT Task, Audio Only (ms) [6]	-

7	8	9	10	11	12	13	adult
-	-	-	-	-	-	-	270 (31)
-	-	-	-	-	-	-	449 (51)
-	-	-	-	-	-	-	704 (132)
~400		~350			~320		~300



The results from these publications show that older participants perform more quickly on average than younger participants on Simple RT tasks, and Choice RT tasks. Furthermore, children exhibit superior performance on auditory and visual stimuli than

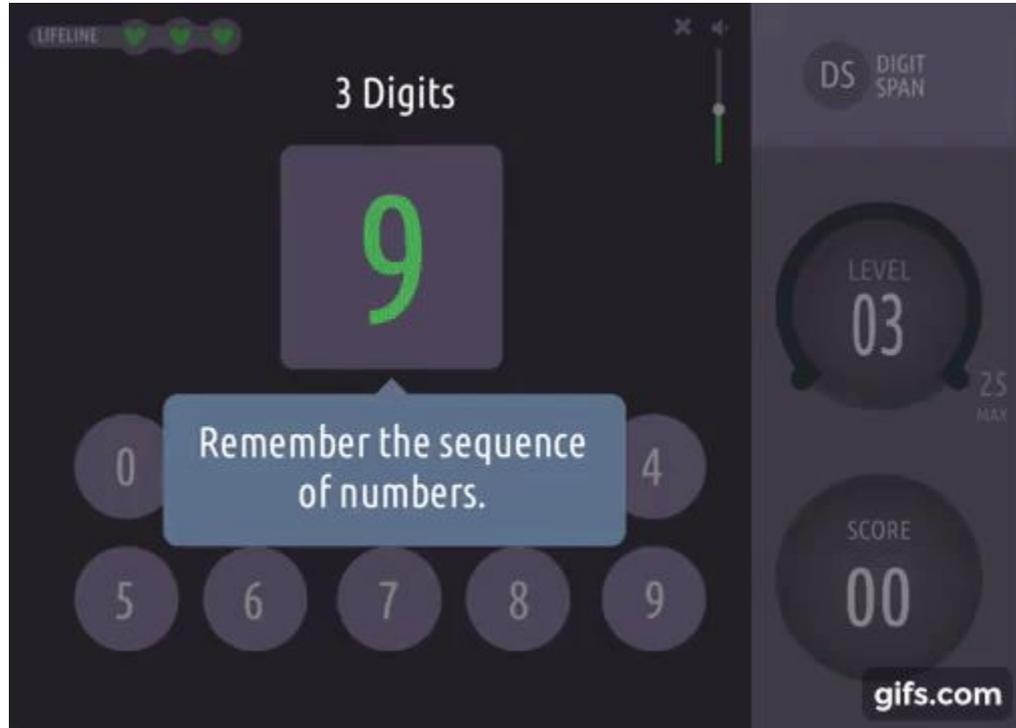
Older participants perform more quickly on average than younger participants on Simple RT tasks, and Discrimination

Children **cannot** perform well enough to spoof adults! (in theory)

Age Performance for Different Tasks

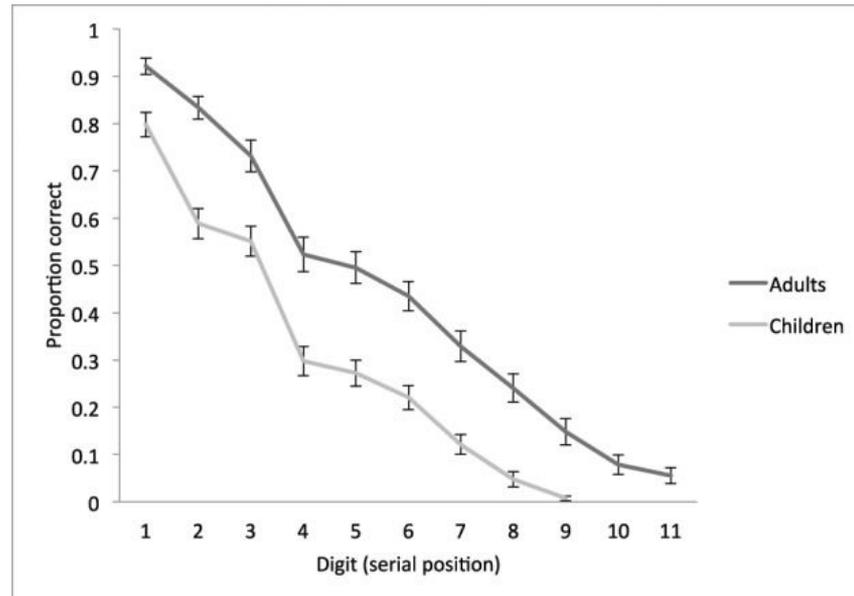
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Stroop C, Computer, Congruent Only, Per Item (ms) [34]	-	-	-	-	-	613 (15.92)					582.4 (11.81)
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Simple RT Task, Audio Only (ms) [6]	-	-	-	~400			~350			~320	~300

How it Works: Digit Span



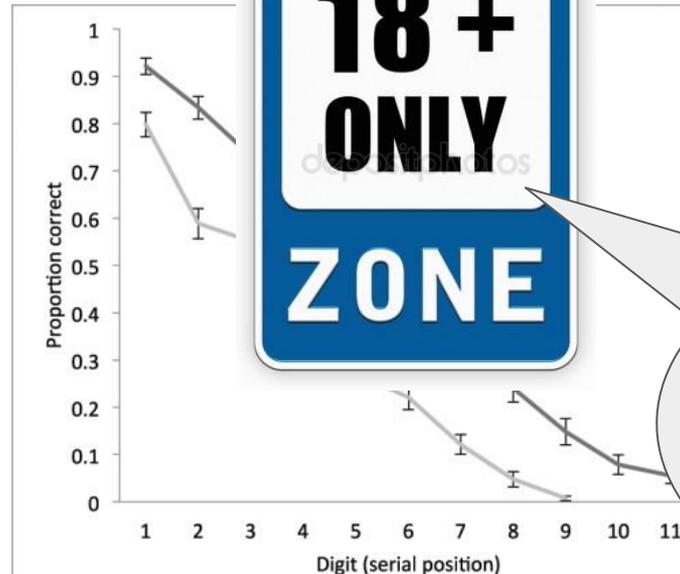
Age Performance for Digit Span

The results from these papers show that **adult participants** have **higher digit spans** than children.



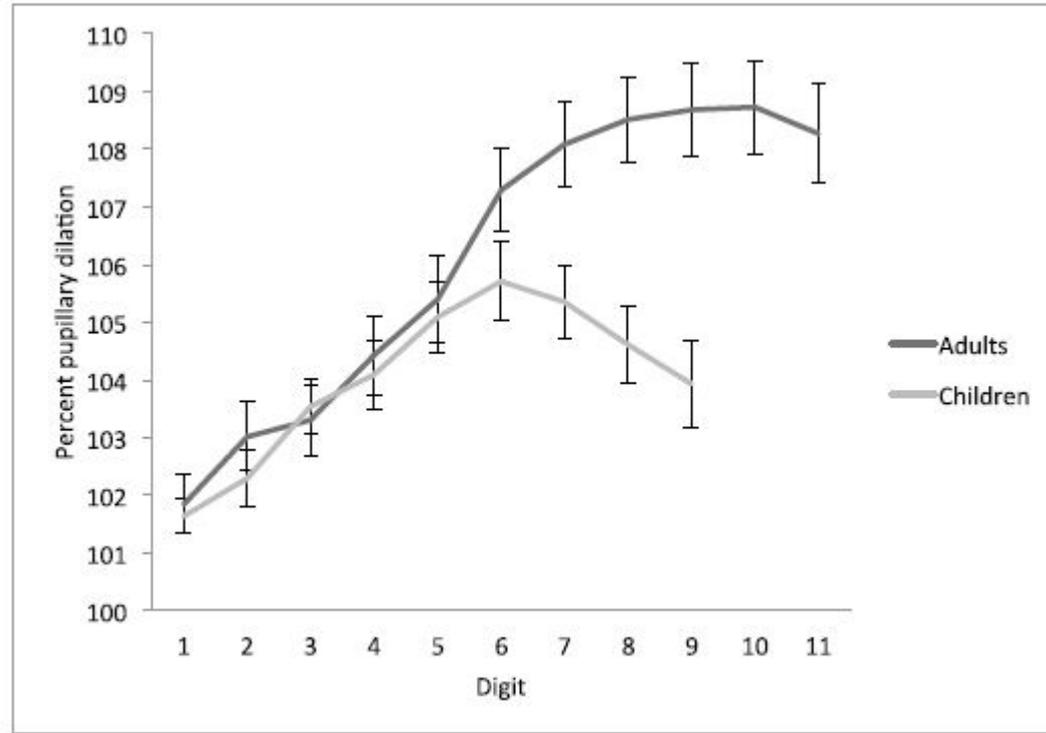
Age Performance for Digit Span

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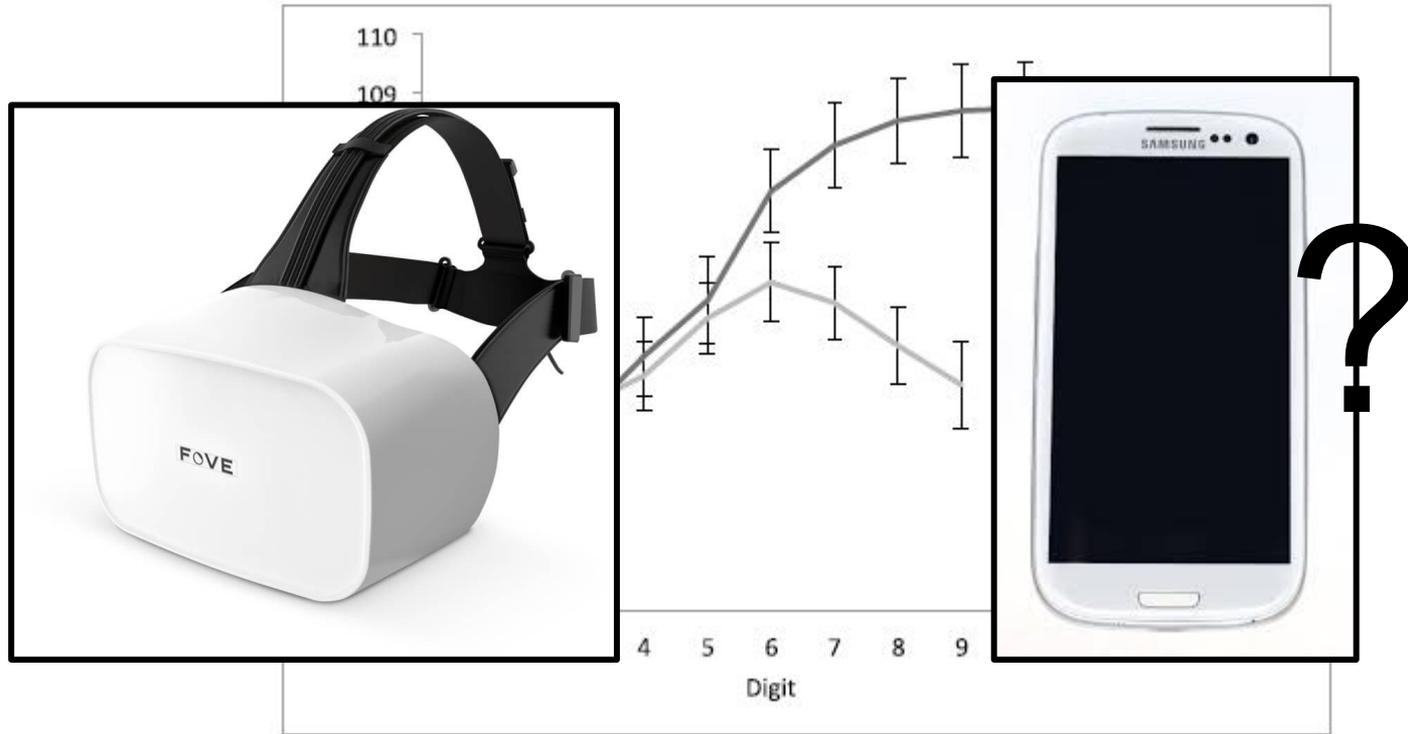
Children **cannot** perform well enough to spoof adults! (in theory)

Physiological Responses!



Johnson et al. Task-evoked pupillometry provides a window into the development of short-term memory capacity. *Frontiers in Psychology*, 2014

Physiological Responses!



Johnson et al. Task-evoked pupillometry provides a window into the development of short-term memory capacity. *Frontiers in Psychology*, 2014

Age Performance for Digit Span (with Pupillary Responses)

The results from publications show that adult participants have higher digit spans than children; additionally, **the pupils of adults and children reach maximum pupil dilation at different digit spans.**

Age Performance for Digit Span (with Pupillary Responses)

The results from pub
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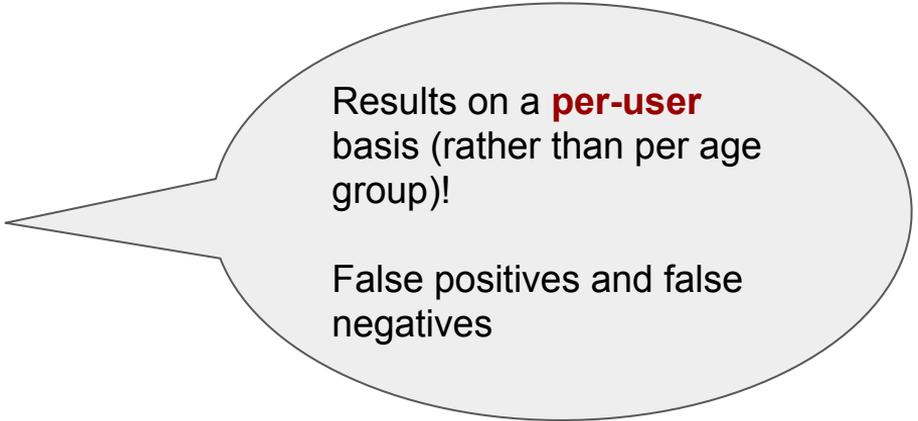
higher digit spans
reach **maximum**

Children **cannot** perform well enough to spoof adults! (in theory)

Adults **cannot** control their pupil dilation to match children's curve (in theory)

What's Next?

- Testing with children and adults
- Combining tests to increase accuracy
- Adding more tests (Mosquito Sound Effect)
- Gamify age verification test



Results on a **per-user** basis (rather than per age group)!

False positives and false negatives

Resistant to spoofing



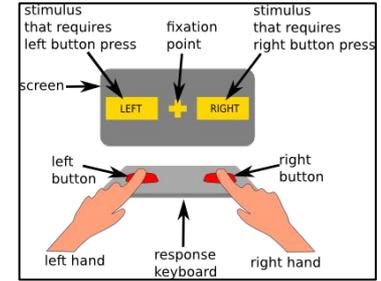
Logistically feasible



Questions?

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Privacy-respecting



RED	BLUE	GREEN	YELLOW	RED
RED	BLUE	GREEN	YELLOW	RED
RED	BLUE	GREEN	YELLOW	RED

