Faster Saliency-Driven Visual Search in Toddlers with High Touchscreen Use

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During toddlerhood – a peak period of neurocognitive development – increased exposure to sensory stimulation through touchscreen use may influence developing attentional control.[1] While TV's rapidly changing, non-contingent flow of sensory information has been hypothesised to lead to difficulties voluntarily focusing attention[2], video-gaming's contingent and cognitively demanding sensory environments may improve visual processing and attention.[3] Toddler touchscreen use involves both exogenous attention, driven by salient audio-visual features, and endogenous/voluntary control, e.g. video selection and app use.[4,5]

The current study compared high and low touchscreen users on a gaze-contingent Visual Search paradigm[6], assessing exogenous, saliency-based attention (single-feature trials) and endogenous attention control (conjunction trials).

Methods

Fifty-six 12-month-olds were recruited (October 2015–March 2016; TABLET project[a5]) and followed longitudinally at 18 months (N=49) and 3.5 years (N=46). Parents gave informed, written consent (Birkbeck Psychology ethical approval 151639/171821). Before each visit, parents were asked: 'On a typical day, how long does your child spend using a touchscreen device (tablet, smartphone or touchscreen laptop)?'. Participants were recruited as 'high-users' (HU) and 'low-users' (LU) based on 10 minutes/day median use reported in a previous survey sample.[5] At 18 months and 3.5 years, user-groups were reassigned using the within-sample median (15 minutes/day). At recruitment, groups were matched on developmental level (*Mullen Scales of Early Learning*), age, sex, background TV (parent-reported minutes/day) and mother's education.

[a] www.cinelabresearch.com/tablet-project

The Visual Search task was administered at 18 months and 3.5 years (Tobii TX300 eye-tracker with 120Hz tracking, 60cm distance, 5-point calibration). Arrays were presented – single-feature (target red apple among blue apples, set-sizes 5 and 9) or conjunction (target red apple among blue apples and slices of red apples, set-sizes 5, 9 and 13; only set-sizes matched across conditions were analysed, i.e. 5 and 9) – for 4 seconds or until the target was fixated. Trials were presented continuously, grouped into blocks: 1) 3 single-feature, fixed-order; 2) 1 single-feature, 9 conjunction, randomised; 3) 4 single-feature, 9 conjunction, randomised.

Results

Data quality and accuracy did not differ significantly across groups. Linear Generalised Estimating Equations for saccadic reaction time (SRT) were run with an unstructured correlation matrix (deviation from pre-registered 3.5-year ANOVA[b]) to include missing data and treat group as a time-varying predictor (some children changed user-group over time; usage correlations: 12-18 months r_s=0.78; 18 months-3.5 years r_s=0.33; 12 months-3.5 years r_s=0.31).

User groups did not differ significantly in conjunction SRTs, but HUs were *faster* than LUs in single-feature trials (p=.001; Table 1). Post-hoc analyses showed faster SRTs for HUs versus LUs in Block 1 single-feature trials (Bonferroni-corrected p=.003) with no group difference in remaining single trials (Bonferroni-corrected p=.75).

Follow-up multiple regressions tested the specificity of concurrent versus longitudinal associations. At 18 months, duration of concurrent use was associated with single-feature SRT (β=-.62, p=0.03), over and above 12-month usage (β=.48, p=.09). At 3.5 years, concurrent use was marginally associated with single-feature SRT (β=-.35, p=.05), with no association at 12 (β=.18, p=.65) or 18 months (β=-.02, p=.96).

[b] https://osf.io/fxu7y

Discussion

Toddler touchscreen use is associated with faster single-feature but not conjunction search, indicative of greater saliency-driven attention without impaired endogenous control. Results are specific to concurrent usage, suggesting recent touchscreen experience may prime attention for exogenous control. Faster HU SRTs in Block 1 suggest a possible saliency bias coming into the task, rather than faster within-task learning. The real-world consequences, particularly when saliency and endogenous goals conflict (e.g. focusing on schoolwork in a busy classroom), remain to be established. Future studies should employ objective tracking of the child's complex media environment to assess the specificity across platforms, content and type of use, as well as establishing whether touchscreen use has a *causal influence* on attention control.

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Figure 1a&b Visual Search Reaction Times (SRTs). Shaded areas represent standard error of the mean.

Table 1. GEE for Visual Search saccadic reaction times predicted by concurrent usage group, visit (18 months, 3.5 years), search type (single, conjunction) and set size (5,9).

	Wald χ^2 (df), p value
Main model including Search Type	
Visit	**11.46 (1), p = 0.001**
Search Type	**119.62 (1), p < 0.001**
Set Size (5, 9)	**6.07 (1), p = 0.01**
Group	**9.83 (1), p = 0.002**
Visit * Set Size	0.33 (1), p = 0.57
Visit * Search Type	2.74 (1), p = 0.10
Visit * *Group*	0.38 (1), p = 0.54
Search Type * Set Size	**4.06 (1), p = 0.04**
Set Size * *Group*	0.005 (1), p = 0.94
Search Type * *Group*	1.89 (1), p = 0.17
Visit * Search Type * Set Size	2.00 (1), p = 0.16
Visit * Set Size * *Group*	0.01 (1), p = 0.91
Visit * Search Type * *Group*	0.85 (1), p = 0.36
Search Type * Set Size * *Group*	0.09 (1), p = 0.77
Visit * Set Size * Search Type * *Group*	**4.01 (1), p = 0.045**
Follow-up model restricted to single search	
Visit	**13.41 (1), p < 0.001**
Set Size (5, 9)	2.73 (1), p = 0.10
Group	**10.45 (1), p = 0.001**
Visit * Set Size	0.61 (1), p = 0.44
Visit * *Group*	< 0.001 (1), p = 0.99
Set Size * *Group*	0.006 (1), p = 0.94
Visit * Set Size * *Group*	2.94 (1), p = 0.09
Follow-up model restricted to conjunction search	
Visit	1.17 (1), p = 0.28
Set Size (5, 9)	**6.15 (1), p = 0.01**
Group	0.12 (1), p = 0.73
Visit * Set Size	1.55 (1), p = 0.21
Visit * *Group*	0.05 (1), p = 0.82
Set Size * *Group*	< 0.001 (1), p > 0.99
Visit * Set Size * *Group*	1.10 (1), p = 0.30