

## Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

**eTable 1:** Educational content description

Article	Definition of Educational Content
Alloway (2014) <sup>1</sup>	Children’s educational programs (e.g., Blue Peter) and baby educational DVDs (e.g., Baby Einstein).
Arraf (1991) <sup>2</sup>	Educational programming broadcasted mainly by the Public Tv station (PBC), in addition to any taped educational TV content (VCR, pay channels).
Barr (2010) <sup>3</sup>	Programs created for preschool audiences and younger and included PBS preschool programs (e.g., Arthur, Sesame Street, and Clifford), Nickelodeon preschool programs (e.g., Blues Clues and Dora the Explorer), baby-directed videos (e.g., Baby Mozart), and Disney movies (e.g., Finding Nemo).
Hudon (2013) <sup>4</sup>	Four programs which have been previously correlated with increased vocabulary scores qualified as “educational programs.” These programs included: Blue’s Clues, Dora the Explorer, Sesame Street, and Go, Diego, Go.
Rice (1990) <sup>5</sup>	Sesame Street.
Selnow (1982) <sup>6</sup>	Electric Company, Sesame Street, Mr. Rogers.
Tomopoulos (2010) <sup>7</sup>	Educational young child–oriented programs consisted primarily of those with educational content intended for children 2 to 6 years old, including live action and animated programs (e.g., Sesame Street and Blue’s Clues). In addition, media marketed as infant-directed and educational (e.g., Baby Einstein and Brainy Baby) was also included in this category.
Wright (2001) <sup>8</sup>	Child-audience, informative or educational programs (regardless of animation). These programs included: Sesame Street, Mister Rogers’ Neighborhood, Reading Rainbow, Captain Kangaroo, Mr. Wizard’s World, and 3-2-1 Contact.
Yang (2017) <sup>9</sup>	Live educational children’s programs (e.g., Tree of Knowledge), and educational cartoons (e.g., Dora the Explorer, Rainbow Cat, Blue Rabbit).
Zimmerman (2007) <sup>10</sup>	Children’s educational programs on television (e.g., Sesame Street, Blue’s Clues, Arthur), and children’s educational programs on DVD/video (e.g., Sesame Street on DVD).

**eTable 2: Search Strategy**

<b>Databases:</b> MEDLINE, Embase, PsycINFO <1806 to March Week 3 2019> <sup>1</sup>	
<b>Search Strategy:</b>	
1	exp television/ or screen time/ (8531)
2	exp computers/ (18918)
3	human computer interaction/ or computer usage/ (10543)
4	mobile devices/ or cellular phones/ (2180)
5	internet/ or internet usage/ or internet addiction/ (31172)
6	("cell phone*" or "i-pad*" or "i-phone*" or "mobile phone*" or "smart phone*" or "video console*" or "video game*" or cellphone* or cellular or computer* or device* or internet* or ipad* or iphone* or "screen time" or smartphone* or tablet* or television* or TV*).mp. (251532)
7	or/1-6 (251726)
8	oral communication/ or verbal communication/ or verbal ability/ or verbal fluency/ (37394)
9	language proficiency/ or pragmatics/ (9013)
10	language/ or vocabulary/ (47285)
11	language disorders/ or communication disorders/ or specific language impairment/ or language delay/ (10520)
12	language development/ (25169)
13	communication skills/ (7073)
14	communication/ (24319)
15	(speech* or language* or verbal* or pragmatics or vocabulary or communication).mp. (573360)
16	or/8-15 (573360)
17	7 and 16 (52363)
18	(infan* or newborn* or new-born* or neonat* or baby or babies or child* or toddler* or boy* or girl* or p?ediatric*).mp. (839699)
19	7 and 16 and 18 (8150)
20	limit 17 to (100 childhood <birth to age 12 yrs> or 120 neonatal <birth to age 1 mo> or 140 infancy <2 to 23 mo> or 160 preschool age <age 2 to 5 yrs> or 180 school age <age 6 to 12 yrs>) (6581)
21	19 or 20 (9875)
22	limit 21 to yr="1960 -Current" (9770)

<sup>1</sup> Example provided is PsycINFO search

**eTable 3.** Criteria for Assessing Study Quality for All Studies Included in the Meta-analysis<sup>1</sup>

1. Question	Was the research question or objective in this paper clearly stated?	0 = No 1 = Yes
2. Defined Sample	Study has a defined eligibility and exclusion criteria for their sample; and time period (dates) and location(s) of recruitment and assessment.	0 = No 1 = Yes
3. Representative Sample	Is the sample representative of a defined population? (i.e. was everyone included who should be and is this sample generalizable)  0 = Single site clinical studies or select sample (e.g., only selecting mothers of children with disabilities). 1 = Cohorts recruited from the general population or from multi-site studies and/or large databases.	0 = No 1 = Yes
4. Adequate Sample Size	Power calculation provided	0 = No 1 = Yes
5. Participation/Attrition	Does the study meet satisfactory participation/attrition rates?  0= <60% participation; >40% attrition or not specified 1= 60-79% participation; 21-39% attrition 2= >80% participation, <20% attrition	0 = Not-acceptable 1= Marginally acceptable 2 = Acceptable
6. Exposure	For the analyses in this paper, was the exposure of interest (screen time) measured prior to the outcome(s) being measured?	0 = No 1 = Yes
7. Level of Exposure	Did the study examine different levels of the exposure (Screen) as related to the outcome (e.g., high versus low users, or exposure measured as continuous variable)?	0 = No 1 = Yes
8. Valid Instrument (Screen time)	Does the study use a validated instrument for the assessment of screen time?  0 = Non-validated (made up by researcher, diary, number of hours) 1= validated measure (e.g. passive sensing, home or inperson observation)	0 = Non-validated 1 = Validated
9. Valid Instrument (Language Outcome)	Does the study use a validated instrument for the assessment of language?  0 = Non-validated (made up by researcher) 1= validated measure (PPVT, CDI, etc.)	0 = Non-validated 1 = Validated
10. Adjusted Effects	Does the study control or adjust for co-variates.	0 = No 1 = Yes

<sup>1</sup> Adapted from: **The National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.**

<https://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort>

**eTable 4.** Study Quality Scoring for Each Study Included in the Meta-analysis

Study	Question	Defined Sample	Representative Sample	Sample Size	Attrition	Exposure	Levels of Exposure	Valid Instrument (Screen)	Valid Instrument (Language)	Adjusted Effects	Score (/10)
Allen et al, 1992 <sup>11</sup>	Y	N	N	N	N	N	Y	Y	Y	N	4
Alloway et al, 2014 <sup>1</sup>	Y	N	Y	N	N	N	Y	N	Y	N	4
Arraf, 1990 <sup>2</sup>	Y	N	Y	N	M	N	Y	N	Y	N	5
Barr et al, 2010 <sup>3</sup>	Y	N	N	Y	Y	Y	Y	N	Y	N	7
Bittman et al, 2011 <sup>12</sup>	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Blankson et al, 2015 <sup>13</sup>	Y	N	Y	N	Y	Y	Y	Y	Y	N	8
Byeon and Hong, 2015 <sup>14</sup>	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Castles et al, 2013 <sup>15</sup>	Y	Y	Y	N	N	N	Y	Y	Y	N	6
Chonchaiya and Pruksananonda, 2008 <sup>16</sup>	Y	N	N	N	N	N	Y	N	Y	Y	4
Christakis et al, 2009 <sup>17</sup>	Y	Y	Y	N	Y	N	Y	Y	Y	Y	9
Duch et al, 2013 <sup>18</sup>	Y	N	N	N	M	N	Y	N	Y	Y	5
Hudon et al, 2013 <sup>4</sup>	Y	N	Y	N	M	N	Y	N	Y	Y	6
Lee et al, 2017 <sup>19</sup>	Y	Y	Y	N	Y	N	Y	N	Y	Y	8
Levin, 1978 <sup>20</sup>	Y	N	Y	N	N	N	Y	N	Y	N	4
Lin et al, 2015 <sup>21</sup>	Y	N	Y	N	N	N	Y	N	Y	N	4
Linebarger and Walker, 2005 <sup>22</sup>	Y	N	Y	Y	Y	Y	Y	N	Y	N	8
Linebarger et al, 2013 <sup>23</sup>	Y	N	Y	N	N	N	Y	N	Y	N	4
Masur et al, 2016 <sup>24</sup>	Y	N	Y	N	N	Y	Y	N	Y	N	5

McKean et al, 2015 <sup>25</sup>	Y	Y	Y	N	N	Y	Y	N	Y	N	6
Mendelsohn et al, 2010 <sup>26</sup>	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Moon et al, 2018 <sup>27</sup>	Y	Y	Y	N	Y	N	Y	N	Y	N	7
Nelson, 1973 <sup>28</sup>	Y	Y	Y	N	Y	Y	Y	N	Y	N	8
Pagani et al, 2013 <sup>29</sup>	Y	Y	Y	N	M	Y	Y	N	Y	Y	8
Patterson, 2002 <sup>30</sup>	Y	N	Y	N	N	N	Y	N	Y	N	4
Rice et al, 1990 <sup>5</sup>	Y	Y	Y	N	Y	Y	Y	N	Y	Y	9
Richert et al, 2010 <sup>31</sup>	Y	N	Y	N	Y	N	Y	N	Y	Y	7
Rosenqvist et al, 2016 <sup>32</sup>	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Ruangdaraganon et al, 2009 <sup>33</sup>	Y	Y	Y	N	M	Y	Y	N	Y	N	7
Schmidt et al, 2009 <sup>34</sup>	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Selnow and Bettinghaus, 1982 <sup>6</sup>	Y	Y	Y	N	N	N	Y	N	N	N	4
Taylor et al, 2018 <sup>35</sup>	Y	Y	Y	N	Y	N	Y	N	Y	Y	8
Tomopoulos et al, 2010 <sup>7</sup>	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
van den Heuvel et al, 2019 <sup>36</sup>	Y	Y	Y	N	N	N	Y	N	Y	Y	6
Wright et al, 2001 <sup>8</sup>	Y	Y	Y	N	M	Y	Y	N	Y	N	7
Yang et al, 2017 <sup>9</sup>	Y	N	N	N	N	N	Y	N	Y	N	3
Zimmerman et al, 2007 <sup>9</sup>	Y	Y	Y	N	M	N	Y	N	Y	N	6
Zimmerman et al, 2009 <sup>37</sup>	Y	Y	Y	N	Y	N	Y	Y	Y	Y	9
Total % Yes	100	56.8	86.5	5.4	21.6	37.8	100	13.5	97.3	45.9	

Abbreviations: N, No; Y, Yes; M, Marginal

**eTable 5.** Results of Moderator Analysis for Duration of Screen Use and Child Language

<b>Categorical Moderators</b>	<b>k</b>	<b>Estimate r</b>	<b>95% CI</b>	<b>Q</b>	<b>p- value</b>
<i>Study Design</i>				0.49	.49
Cross-Sectional	24	-.14***	-21 to -.08		
Longitudinal	14	-.12***	-.16 to -.07		
<i>Screen Use Type<sup>a</sup></i>				1.18	.28
Television only	10	-.11***	-.16 to -.05		
Mixture <sup>b</sup>	26	-.15***	-.21 to -.09		
<b>Continuous Moderators</b>	<b>k</b>	<b>b</b>	<b>95% CI</b>	<b>z-value</b>	<b>p- value</b>
Study Year	38	.005	-.000 to .009	1.85	.06
Child Age	38	-.000	-.002 to .001	-0.47	.64
Sex (% male)	38	-.004	-.012 to .004	-0.97	.33
Study Quality	38	.089	-.02 to .039	0.58	.56

k = number of samples

<sup>a</sup> = mobile only (k = 2) not included as k < 3 for categorical comparison

<sup>b</sup> = can include either television, mobiles, video games, and/or computers

**eTable 6.** Results of Moderator Analysis for Background Television and Child Language

<b><i>Continuous Moderators<sup>a</sup></i></b>	<b><i>k</i></b>	<b><i>b</i></b>	<b><i>95% CI</i></b>	<b><i>z-value</i></b>	<b><i>p-value</i></b>
Study Year	5	-.001	-.016 to .014	-0.14	.90
Child Age	5	-.006	-.050 to .038	-0.27	.79
Sex (% male)	5	-.009	-.031 to .048	0.42	.68
Study Quality	5	.000	-.122 to .123	0.01	.99

*k* = number of samples

<sup>a</sup> categorical moderators not conducted as *k* < 10.



**eTable 7.** Results of Moderator Analysis for Educational Screen Use and Child Language

<b>Categorical Moderators<sup>a</sup></b>	<b>k</b>	<b>Estimate r</b>	<b>95% CI</b>	<b>Q</b>	<b>p- value</b>
<i>Study Design</i>				0.25	.62
Cross-Sectional	7	.15	-.03 to .31		
Longitudinal	6	.10	-.00 to .19		
<b>Continuous Moderators</b>	<b>k</b>	<b>b</b>	<b>95% CI</b>	<b>z-value</b>	<b>p- value</b>
Study Year	13	-.009	-.019 to .001	-1.75	.08
Child Age	13	-.001	-.006 to .008	0.20	.84
Sex (% male)	13	-.006	-.032 to .044	0.30	.77
Study Quality	13	.034	-.060 to .074	0.20	.85

k = number of samples

<sup>a</sup> = screen type not included as k < 3 for mobile only and mix comparisons

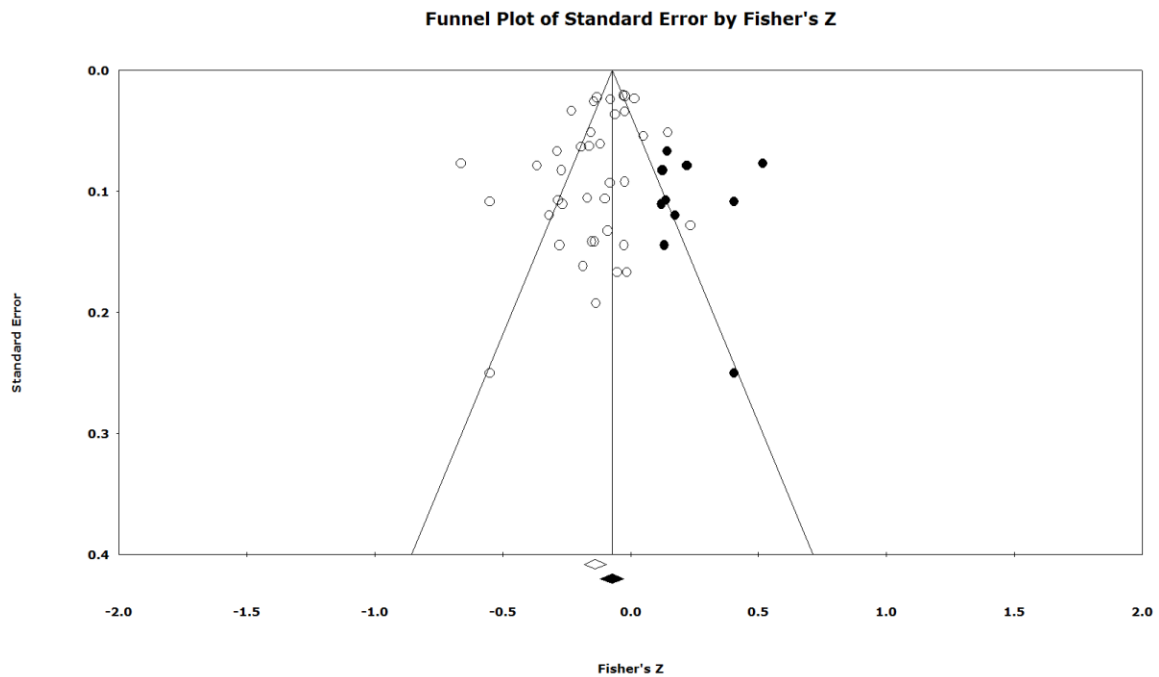
**Table e8.** Results of Moderator Analysis for Co-viewing Screens and Child Language

<b>Categorical Moderators<sup>a</sup></b>	<b>k</b>	<b>Estimate r</b>	<b>95% CI</b>	<b>Q</b>	<b>p-value</b>
<i>Study Design</i>				1.76	.18
Cross-Sectional	8	.19**	.05 to .33		
Longitudinal	4	.08**	.01 to .15		
<i>Screen Use Type<sup>a</sup></i>				0.58	.45
Television only	3	.11**	.01 to .20		
Mixture <sup>b</sup>	9	.11*	.06 to .33		
<b>Continuous Moderators</b>	<b>k</b>	<b>b</b>	<b>95% CI</b>	<b>z-value</b>	<b>p-value</b>
Study Year	12	-.011	-.021 to .000	-1.91	.06
Child Age	12	-.001	-.005 to .003	-0.54	.59
Sex (% male)	12	.028	.006 to .051	2.45	.02
Study Quality	12	-.031	-.087 to .024	-1.11	.27

k = number of samples

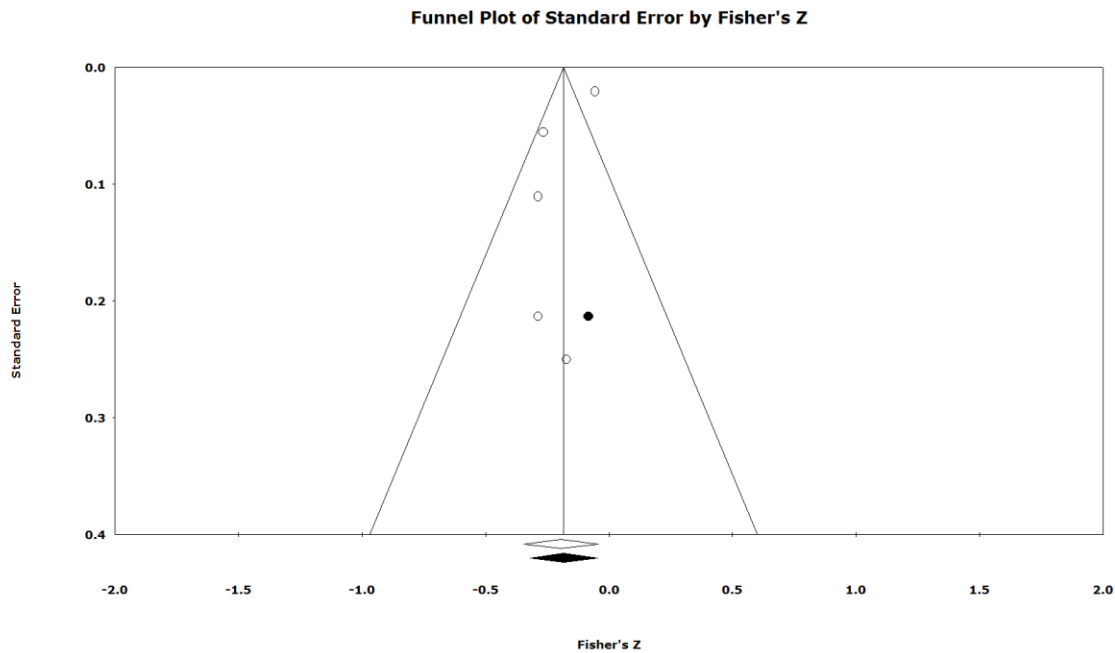
<sup>a</sup> = mobile only (k = 2) not included as k < 3 for categorical comparison

**eFigure 1.** Funnel Plot of Studies Examining Quantity of Screen Use to Child Language



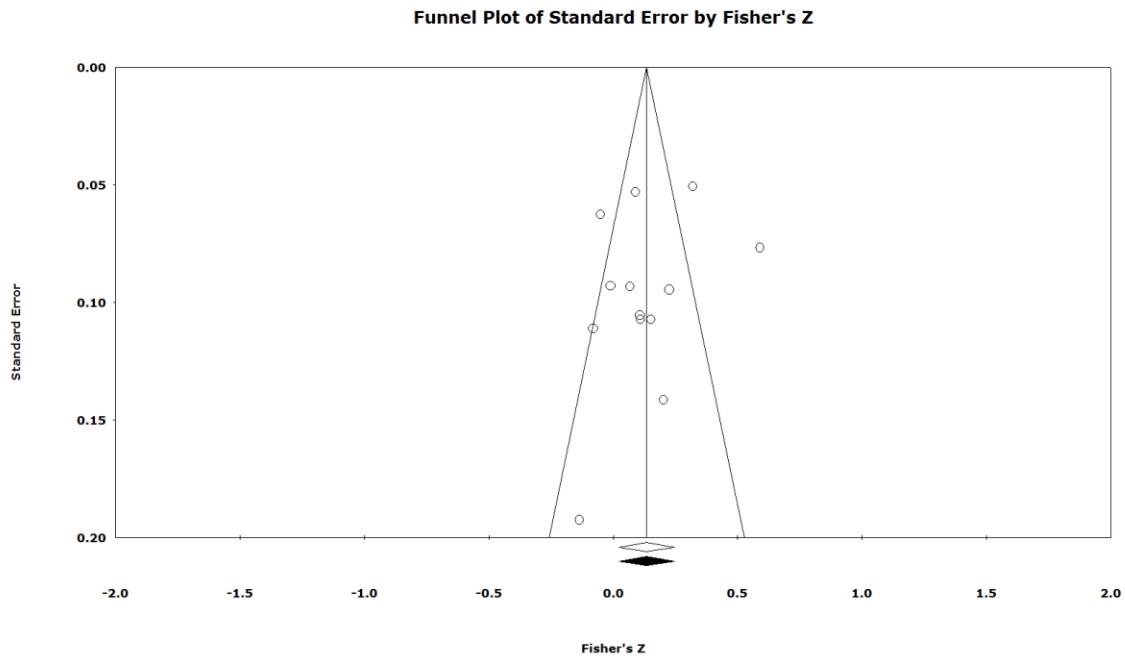
Legend: The funnel plot is a measure of study size (y-axis) as a function of effect size (x axis). Observed studies are indicated by white circles, while dark circles indicate their imputed counterparts when assymtry is detected. The middle vertical line is the mean prevalence estimate, and the contour lines (to its left and right) represent the region within which 95% of observed studies should lie in the absence of publication bias. The white diamond represents the observed mean effect size, and the black diamond represents the adjusted mean effect size. Studies with large sample sizes appear toward the top of the graph, and tend to cluster near the mean effect size, whereas studies with smaller sample sizes appear to the bottom-middle right of the graph. Due to the tendency to have more sampling variation in effect size estimates in studies with smaller sample sizes, these studies will be dispersed across a range of values (bottom-middle right of plot).

**eFigure 2.** Funnel Plot of Studies Examining Background Television to Child Language



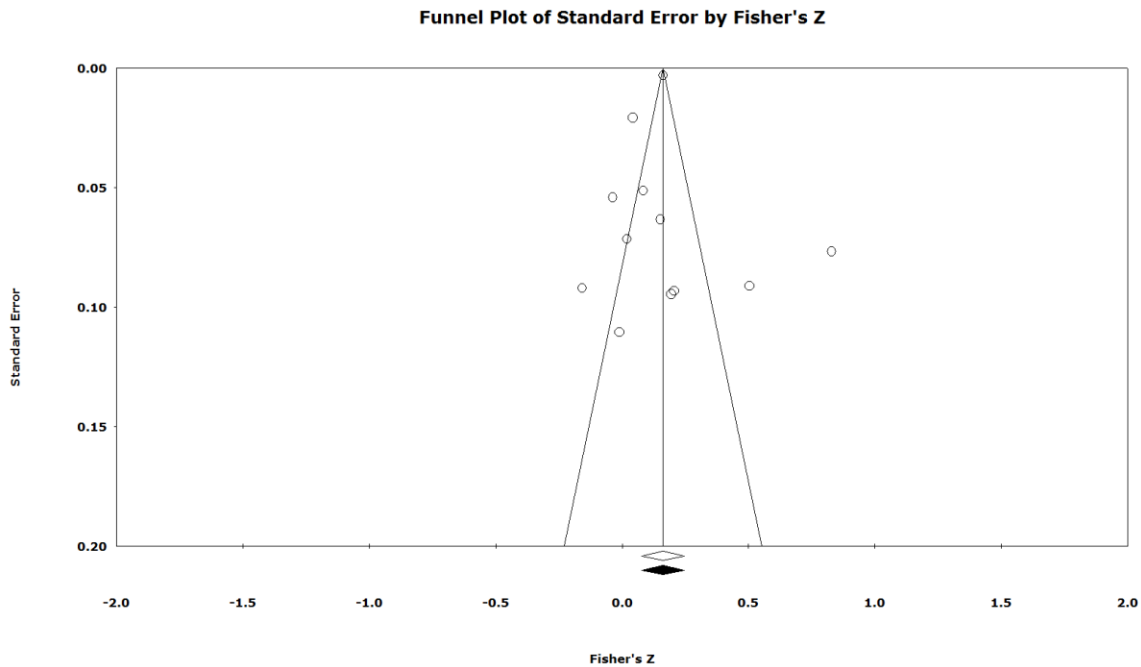
Legend: The funnel plot is a measure of study size (y-axis) as a function of effect size (x axis). Observed studies are indicated by white circles, while dark circles indicate their imputed counterparts when asymmetry is detected. The middle vertical line is the mean prevalence estimate, and the contour lines (to its left and right) represent the region within which 95% of observed studies should lie in the absence of publication bias. The white diamond represents the observed mean effect size, and the black diamond represents the adjusted mean effect size (in the event of asymmetry). Studies with large sample sizes appear toward the top of the graph, and tend to cluster near the mean effect size, whereas studies with smaller sample sizes appear to the bottom-middle right of the graph. Due to the tendency to have more sampling variation in effect size estimates in studies with smaller sample sizes, these studies will be dispersed across a range of values (bottom-middle right of plot).

**eFigure 3.** Funnel Plot of Studies Examining Educational Programming to Child Language



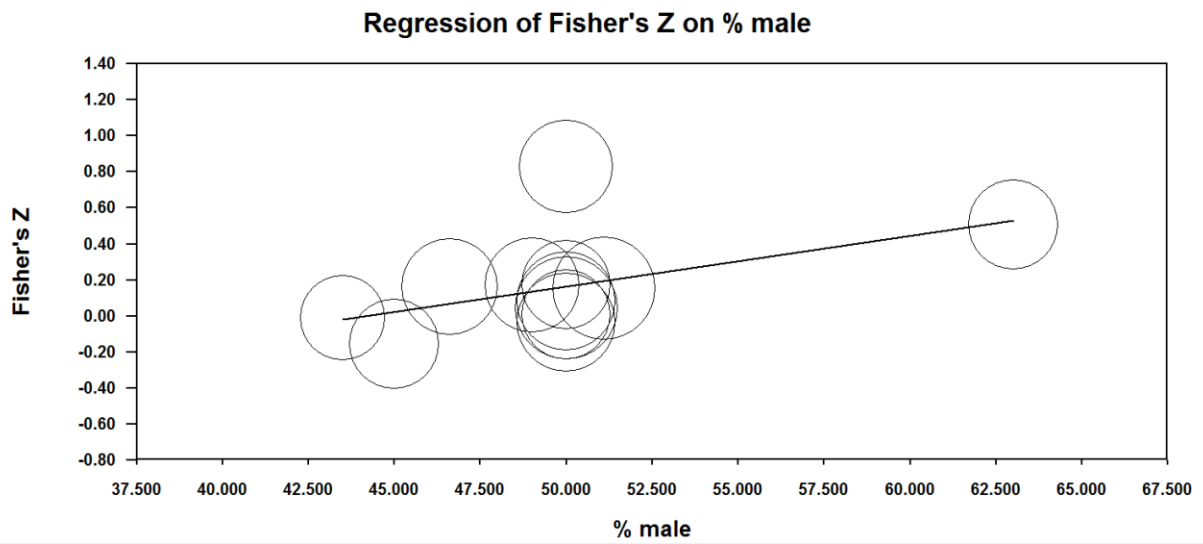
Legend: The funnel plot is a measure of study size (y-axis) as a function of effect size (x axis). Observed studies are indicated by circles. The middle vertical line is the mean prevalence estimate, and the contour lines (to its left and right) represent the region within which 95% of observed studies should lie in the absence of publication bias. The white diamond represents the observed mean effect size, and the black diamond represents the adjusted mean effect size (in the event of asymmetry). Studies with large sample sizes appear toward the top of the graph, and tend to cluster near the mean effect size, whereas studies with smaller sample sizes appear to the bottom-middle right of the graph. Due to the tendency to have more sampling variation in effect size estimates in studies with smaller sample sizes, these studies will be dispersed across a range of values (bottom-middle right of plot).

**eFigure 4.** Funnel Plot of Studies Examining Co-viewing to Child Language

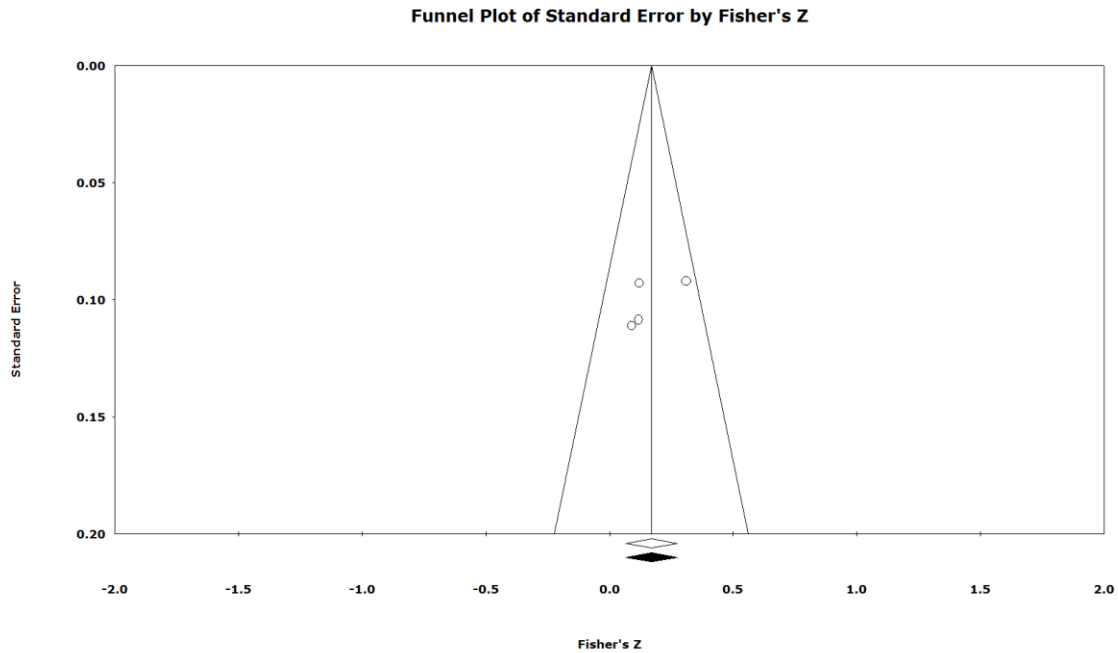


Legend: The funnel plot is a measure of study size (y-axis) as a function of effect size (x axis). Observed studies are indicated by circles. The middle vertical line is the mean prevalence estimate, and the contour lines (to its left and right) represent the region within which 95% of observed studies should lie in the absence of publication bias. The white diamond represents the observed mean effect size, and the black diamond represents the adjusted mean effect size (in the event of asymmetry). Studies with large sample sizes appear toward the top of the graph, and tend to cluster near the mean effect size, whereas studies with smaller sample sizes appear to the bottom-middle right of the graph. Due to the tendency to have more sampling variation in effect size estimates in studies with smaller sample sizes, these studies will be dispersed across a range of values (bottom-middle right of plot).

**eFigure 5.** Meta-Regression Scatterplot Examining Child Sex on the Association between Co-Viewing and Child Language



**eFigure 6.** Funnel Plot of Studies Examining Age of Onset of Screen Use to Child Language



Legend: The funnel plot is a measure of study size (y-axis) as a function of effect size (x axis). Observed studies are indicated by circles. The middle vertical line is the mean prevalence estimate, and the contour lines (to its left and right) represent the region within which 95% of observed studies should lie in the absence of publication bias. The white diamond represents the observed mean effect size, and the black diamond represents the adjusted mean effect size (in the event of asymmetry). Studies with large sample sizes appear toward the top of the graph, and tend to cluster near the mean effect size, whereas studies with smaller sample sizes appear to the bottom-middle right of the graph. Due to the tendency to have more sampling variation in effect size estimates in studies with smaller sample sizes, these studies will be dispersed across a range of values (bottom-middle right of plot).



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