Understanding the impacts of video-guided activities on parent-child interaction

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Abstract

Early parenting practices play an important role in shaping children's future outcomes. In particular, high-quality early interactions can facilitate language learning and school performance. The rise of phone-based parenting applications ("apps") could deliver low-cost interventions on parenting style to a wide variety of populations, especially the parents of very young children, who are often difficult to reach in other ways. Yet little is known about the effects of communicating to parents through app-based interventions. In two studies (one preregistered), we showed parents short videos depicting age-appropriate parent-child activities from a parenting app. We found that after watching the video, parents spoke more and made more bids for joint attention, as compared with controls who watched no video (experiment 1) or a science video (experiment 2). These results suggest that activity videos can lead to positive changes in parent engagement, providing support for the use of such videos in parenting interventions.

Keywords: language development; parent intervention; childhood development; joint attention; lexical diversity

Word count: 4954

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25   Understanding the impacts of video-guided activities on parent-child interaction

Statement of Relevance

27   The way parents play with their young children has important impacts on later

28   learning and school-readiness. Many apps offer advice to parents, but few studies have

29   examined how effectively parents use this advice in real life. We measured how parents

30   played with and spoke to their children after watching a video in a parenting app. Parents

31   made more attempts to engage with their children, and spoke more to them after watching

32   these videos. While younger children (~1 year) did not engage more as a result of their

33   parents' efforts, older children (1.5- to 2-year-olds) showed increasing engagement. The

34   activity videos encouraged parents to set goals for their child during play. Our findings

35   suggest that this type of parent-led play may be most helpful in scaffolding play in older

36   toddlers, and that digital parenting advice could be a valuable tool for families.

Introduction

38   The quantity and quality of early language input has been found to be strongly

39   associated with later language and academic outcomes (Cartmill et al., 2013; Hart &

40   Risley, 1995; Hirsh-Pasek et al., 2015; Marchman & Fernald, 2008; see Schwab &

41   Lew-Williams, 2016 for a review). Thus, because of the potential for large downstream

42   effects (Heckman, 2006), there is tremendous interest in interventions that change

43   children's language environment. And because parents define a large portion of that

44   environment, especially before the onset of formal schooling, parent behavior is a critical

45   locus for such interventions. Many effective parenting interventions require large resource

46   investments and require many hours of in-person contact (Gertler et al., 2014; Leung,

47   Hernandez, & Suskind, 2018; Schweinhart et al., 2004), making implementation at scale a

48   daunting proposition. For this reason, many researchers targeting early language are

49   interested in delivering parenting interventions remotely – through texts, apps, and videos

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⁵⁰ delivered on digital devices. But what do parents take away from these short messages

⁵¹ about what to do with or how to talk with their children?

⁵²   The content provided by digital parenting interventions runs the gamut from general

⁵³ parenting messages and facts from child development research to specific advice and

⁵⁴ suggested activities. A growing body of evidence suggests that these digital interventions

⁵⁵ can be effective across a range of cultures, income levels, and children's ages (for a review,

⁵⁶ see Breitenstein, Gross, & Christophersen, 2014). For example, in contrast to a face-to-face

⁵⁷ parent training intervention, a tablet-based version saw significantly higher session

⁵⁸ completion rates (51% attendance vs. 85% module completion) and comparable or larger

⁵⁹ effect sizes on parents' and children's (aged 2 to 5 years) behavior (Breitenstein, Fogg,

⁶⁰ Ocampo, Acosta, & Gross, 2016). Often, however, the theory of change presupposed by

⁶¹ such interventions is relatively vague. Both within and outside the realm of academic

⁶² interventions, messages to parents of young children often seek to provide knowledge about

⁶³ some aspect of development (e.g., early language), often in tandem with a suggestion

⁶⁴ regarding activities. Such messages are assumed to inform parents' choice of behaviors,

⁶⁵ spurring them to engage in some target activity, which is assumed to be more stimulating

⁶⁶ than what parents would have done otherwise.

⁶⁷   This theory of change is typically grounded in ideas about guided play and early

⁶⁸ language stimulation. Child-directed speech varies not only in quantity (i.e., the number of

⁶⁹ total tokens), but also in quality in terms of the diversity of the tokens (Malvern, Richards,

⁷⁰ Chipere, & Durán, 2004) or the context-appropriateness of the speech (Cartmill et al.,

⁷¹ 2013), both of which have been linked to children's subsequent language development.

⁷² Further, language learning—especially the acquisition of early vocabulary in the first

⁷³ years—appears to be supported preferentially by parents and children *jointly attending* to

⁷⁴ some object or activity (Baldwin, 1991; Bigelow, MacLean, & Proctor, 2004). Episodes of

⁷⁵ joint attention are frequent during guided play, when parents set goals and scaffold their

⁷⁶ child's activities (Weisberg, Hirsh-Pasek, & Golinkoff, 2013; Wood, Bruner, & Ross, 1976).

77 Thus, the current literature supports interventions that encourage parents to provide

78 high-quality language and interaction through something like guided play—whether via

79 reading books or playing with a shape-sorter at home, or via a conversation about

80 categories in the supermarket.

81 But is this theory of change correct? That is, does the provision of knowledge and

82 activities lead to higher-quality play? Alternatively, by focusing parents on a specific

83 activity, this approach could be flawed, causing parents to over-focus on achieving the

84 superficial goals of the activity. This problem might be especially likely with video

85 messages, which could encourage parents to try to mimic a model's specific speech and/or

86 actions. Attempting to reproduce such surface details of a video-guided activity could in

87 turn result in less high-quality talk, with less responsiveness to their child's play. Another

88 possibility is that these messages might produce the desired effect, but only for those

89 parents who already have a general orientation towards children's early learning.

90 Our current experiments were designed to make a direct test of this question: How do

91 parents change their interactions with young children on the basis of short video parenting

92 messages? In two experiments, we collected data from parent-child dyads in a local

93 children's museum. We showed parents in the experimental group a single short video

94 modeling an interactive toy-based activity along with a scientific justification. Parents in

95 the control group received either no video (Experiment 1) or a video of a recent finding in

96 developmental psychology (Experiment 2). We then gave the toys from the video to all

97 dyads and videotaped their interactions, coding for caregivers' language quantity and

98 quality as well as joint attention.

Experiment 1

100 In Experiment 1, we invited parents of 6- to 24-month-old infants visiting a children's

101 museum in XXXX to complete video-guided activities from a commerical parenting app

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that delivers digital parenting advice in the form of short videos. Parents were randomly

assigned to one of two conditions: parents in the *Activity Video* condition watched a video

from the app (matched to their child's age), and then performed the activity with their

child using the props from the video. Parents in the *No Video* condition did not watch an

activity video, but were given a set of the same age-appropriate props and asked to play

with their infants as they normally would at home.

Method

Participants.   60 infants (F = 43, M = 17) aged 6-24 months (19 6-11.9

month-olds: 9 in the control condition, 10 in Activity Video; 20 12-17.9 month-olds: 11

control, 9 Activity Video; 21 18-24 month-olds: 10 control, 11 Activity Video) and their

parents participated in a museum in XXXX. We included infants who were exposed to

English at least 50 percent of the time (n = 58) or who were exposed less but whose

participating parent reported that they primarily speak English with their child at home (n

= 2). 62% of participants (n = 37) had been exposed to two or more languages, as

indicated by their parent. Parents identified their children as White (n = 25), Asian (n =

11), African American/Black (n = 2), Biracial (n = 12), other (n = 5), or declined to state

(n = 5). Fifteen parents reported that their child was of Hispanic origin. Parents tended to

be highly-educated, with reports of highest level of education ranging from completed high

school (n = 5), some college (n = 7), four-year college (n = 16), some graduate school (n =

2), to completed graduate school (n = 30).

Materials.   Stimuli included activity videos from a commercial parenting

application. The videos were designed to show activities to parents that they could perform

with their child in order to foster cognitive and physical development, and were targeted to

the child's age and level of development. In each video, an adult and child perform the

activity (e.g., sorting toys according to size) while a narrator explains the activity and its

purpose. We selected two videos for each of three age groups in our sample (6-11.9 months,

128 12-17.9 months, 18-23.94 months). Participants were also given a set of toys corresponding

129 to those in the video that they watched so that they could complete the activity.[1]

130 Participants were randomly assigned to either the *Activity Video* condition or the *No*

131 *Video* condition. Parents participating in the Activity Video condition were assigned to

132 watch one of the two activity videos available for their child's age group, while parents in

133 the No Video condition watched no video, and were simply asked to play with their child

134 as they normally would. The two conditions were yoked: for each Activity Video

135 participant who saw a particular video and received the associated props, a participant in

136 the No Video condition received the same props to use without seeing the video. Parents

137 also completed the Early Parenting Attitudes Questionnaire (EPAQ; Hembacher & Frank,

138 2020). The EPAQ measures parents of young children's attitudes about parenting and

139 child development along three dimensions: rules and respect, early learning, and affection

140 and attachment (see SI).

141 **Procedure.**   After providing informed consent, parents in the Activity Video

142 condition watched the assigned activity video on a laptop with headphones. To ensure that

143 parents could give the video their full attention, the experimenter played with the infant

144 with a set of toys (different from the experimental props used in the study) while the video

145 was being played. Immediately following the video, each parent-child dyad was provided

146 with the props to complete the video-guided activity that the parent had viewed. The toys

147 were placed on a large foam play mat, and parents were instructed to sit on the mat with

148 their child and re-create the activity they had viewed for a period of approximately three

149 minutes.[2] In the No Video condition, after informed consent parents were told to play with

150 their child as they would at home with the provided props for a period of three minutes.

151 They were not given any additional instructions about how to use the props.

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[1] Details of the specific videos used and the toys associated with each video are in the Appendix.

[2] Based on piloting, we estimated these activities would would only require three minutes to complete.

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152   In both conditions, two video cameras were used to record the play session from

153 different angles, and parents were fitted with a wireless Shure lavalier microphone to record

154 their child-directed speech. After three minutes of play had elapsed, parents were told they

155 could stop playing and the cameras and microphone were turned off. Parents were then

156 asked to complete the EPAQ before being debriefed.

157   **Joint Attention Coding Procedure.**   The video of each session was manually

158 coded for episodes of joint attention (JA) using the Datavyu software (Team, 2014). The

159 video taken at floor level was coded by default, but the other video was referred to if the

160 participants were occluded or if there was technical difficulty with the first camera. Each

161 session's video was coded for episodes of coordinated JA, episodes of passive JA, and

162 parental bids for JA. Parental bids for JA were defined as any attempt to initiate joint

163 attention (i.e labeling, pointing, or otherwise drawing attention to an object) that did not

164 result in passive or coordinated JA. If more than 3 seconds elapsed between bids, they were

165 coded as separate attempts. An episode of joint attention was considered *passive* if both

166 participants visually focused on an object for 3 or more seconds but the child did not

167 acknowledge the parent. If either participant looked away from the object for less than 3

168 seconds and then returned to the same object it was considered part of the same episode of

169 joint attention. A joint attention episode was considered *coordinated* if both participants

170 visually focused on an object for 3 or more seconds and at some point in the interaction

171 the child indicated awareness of interaction with some overt behavior toward the parent

172 such as looking at their face, gesturing, vocalizing, or turn-taking. Full details of our

173 guidelines for coding joint attention are available in SI.

174   A second coder independently coded a third of the videos (i.e., 20 of the 60 videos,

175 approximately equally distributed across ages) to establish reliability. The two coders had

176 a reliability of ICC = 0.79 with 95% confidence interval (CI) = [0.55, 0.91] for rate of

177 parent bids for JA (number of bids per minute); ICC = 0.34 with 95% CI = [-0.11, 0.67]

178 for rate of passive JA episodes (per minute); ICC = 0.66 with 95% CI = [0.32, 0.85] for

179 rate of coordinated JA episodes; ICC = 0.33 with 95% CI = [-0.11, 0.67] for time spent

180 (seconds per minute) in passive JA episodes, and ICC = 0.60 with 95% CI = [0.24, 0.82]

181 for time spent in coordinated JA episodes.

Results

183 Parents' child-directed speech during the play sessions (mean duration: 3.25 min) was

184 transcribed; child utterances were not considered. Although Experiment 1 was not

185 preregistered, for consistency the transcripts and hand-coded joint attention data were

186 analyzed according to our preregistration for Experiment 2[3], with any deviations or

187 exploratory analyses noted. Below we first report the lexical diversity results, followed by

188 the joint attention results.

189 **Lexical Diversity.** For each transcript of child-directed speech, the caregivers'

190 unique word *types* and *tokens* (total words) uttered were tallied and converted to rates

191 (e.g., tokens per minute of play), and the type-token ratio (TTR) was calculated as a

192 measure of lexical diversity. Although we initially preregistered TTR as our measure of

193 lexical diversity (since it is a simple, commonly used measure), it has been noted that TTR

194 is correlated with the length of a text, which has led to the development of new measures

195 such as the measure of textual lexical diversity (MTLD; McCarthy & Jarvis, 2010). Thus,

196 we also measure lexical diversity with MTLD, which is calculated as the mean length of

197 sequential word strings in a text that maintain a given TTR value (we use 0.72, as

198 proposed by McCarthy & Jarvis).

199 We fit a Bayesian mixed-effects linear regression predicting TTR as a function of

200 condition, age (centered), and their interaction with a random intercept per video using

201 rstanarm (Goodrich, Gabry, Ali, & Brilleman, 2018). For effects that are at least 95%

202 likely to be non-zero according to the posterior distribution (i.e., probability of direction:

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[3] Preregistration: https://osf.io/6k9m8/

203 *pd*; Makowski et al. (2019a)), we report estimated coefficients (β) as well as 89% Bayesian

204 credible intervals (89% CI)[4], demarcating the range within which 89% of the posterior falls,

205 meaning that given the observed data, the effect has 89% probability of falling within this

206 range (see Appendix for more an illustrated explanation). There was lower TTR in the

207 Activity Video condition (mean: 0.32) than in the No Video condition (mean: 0.43,

208 β =-0.11, 89% CI = [-0.15, -0.07], *pd* = 1). A similar regression instead predicting MTLD

209 also found lower lexical diversity in the Activity Video condition (mean MTLD: 17.87)

210 than in the No Video condition (mean: 27.09, β =-9.25, 89% CI = [-14.25, -4.16], *pd* = 1),

211 with no notable influence of age. Figure 1 (top) shows the mean of each lexical diversity

212 measure (TTR and MTLD) by condition.

213   We also conducted similar regressions predicting the rate of word tokens and types

214 per minute of play, finding a notable effect of condition on the rate of word tokens (β =

215 16.56, 89% CI = [6.38, 27.27], *pd* = 0.99), with parents using tokens at a higher rate in the

216 Activity Video condition (mean: 69 tokens/min, bootstrapped 95% confidence interval

217 (conf. int.): [60, 79]) than in the No Video condition (mean: 52, 95% conf. int.: [44, 61]).

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[4] 89% CIs are recommended for Bayesian analyses because unless the effective sample size (ESS) is on the

order of 10,000, the 95% credible interval is unstable (Kruschke, 2014; Makowski et al., 2019b; McElreath,

2018). Our ESS ranges from 2,000-5,000, and thus we report the tighter, more stable interval.
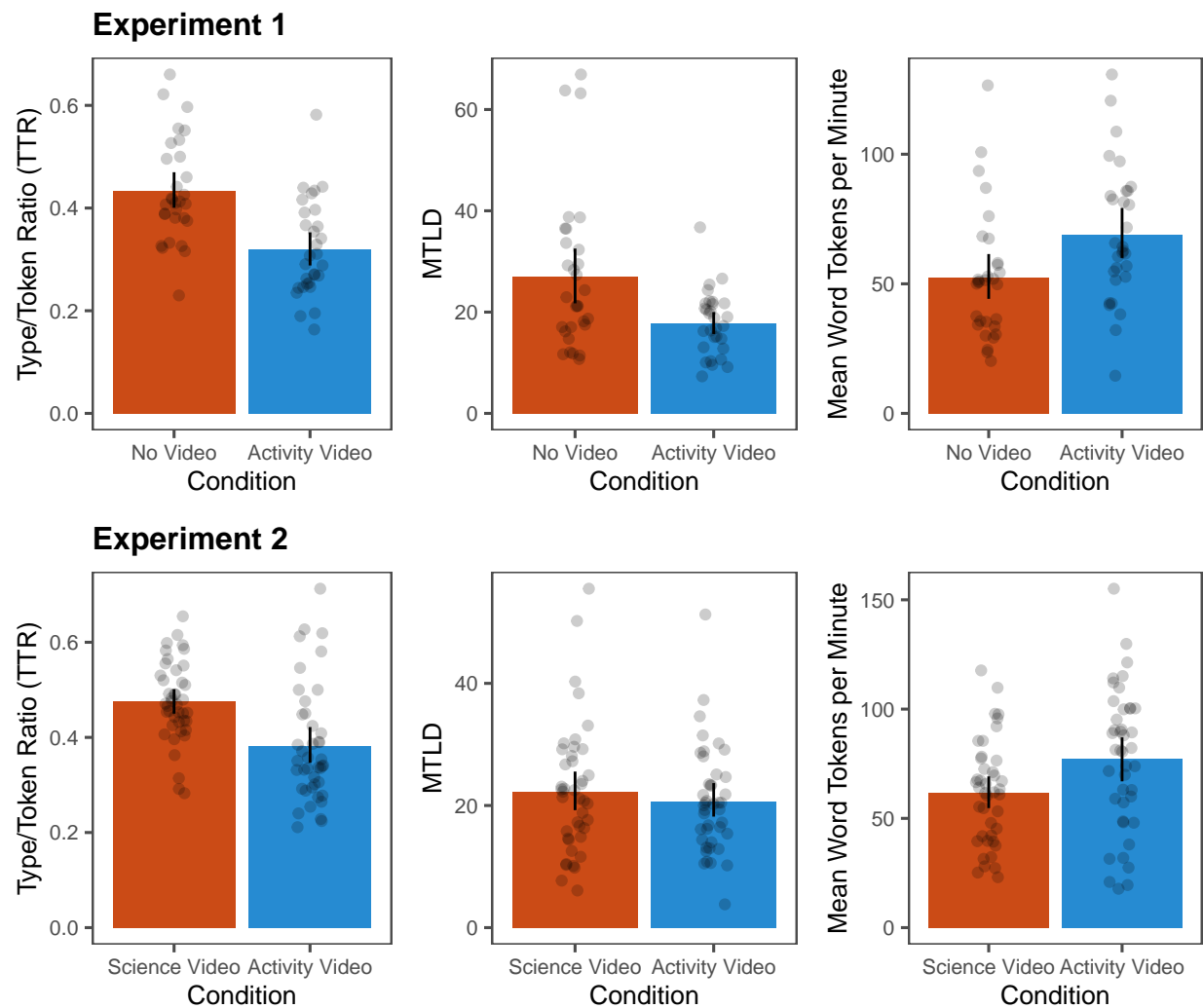
Figure 1. Mean lexical diversity scores (left: Type/Token ratio, middle: MTLD) and mean number of tokens used by condition (right) in Experiment 1 (top) and Experiment 2 (bottom). Error bars show bootstrapped 95% confidence intervals, and gray dots indicate values for each participant.

Joint Attention. We fit a Bayesian mixed-effects linear regression predicting the rate of parent bids (per minute) for joint attention (JA) as a function of fixed effects of condition, age (centered), and their interaction, with random intercepts per video. Parents' bid rate was greater in the Activity Video condition (mean: 3, sd: 1.11) than in the No Video condition (mean: 2.15, sd: 1.02, $\beta = 0.72$, 89% CI $= [0.14, 1.32]$, $pd = 0.98$). Mixed-effects regressions with the same structure were performed predicting the rate of

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224 episodes of coordinated and passive JA, and the time spent in coordinated and passive JA.

225 There were no notable effects on the rate of episodes nor on the time spent in coordinated

226 or passive JA episodes. Figure 2 (top) shows the mean rate of bids and episodes of JA by

227 condition in Experiment 1.

228 **Exploratory Analyses.**   We also fit Bayesian mixed-effects linear regression

229 models predicting each of the above lexical diversity and joint attention dependent

230 variables as a function of fixed effects of condition, age (centered), the child's sex, parent's

231 education level, and the subscales of the EPAQ: Early Learning (EL), Affection and

232 Attachment (AA), and Rules and Respect (RR), along with interactions of condition and

233 EL, AA, and RR. These models included random intercepts per video. Of these

234 exploratory regressions, two showed notable effects involving the EPAQ subscales, and one

235 other showed an effect of the child's sex. First, in the word types regression, parents with

236 higher Affection and Attachment scores used more word types per minute after watching

237 an Activity Video (interaction of condition and AA: $\beta = 6.85$, 89% CI = $[0.74, 12.91]$, $pd =$

238 0.96). Second, in the regression examining the rate of passive JA episodes, parents scoring

239 higher on the Rules and Respect (RR) subscale had a lower rate of passive JA episodes

240 $(\beta = -0.35$, 89% CI = $[-0.63, -0.06]$, $pd = 0.97$). However, after an Activity Video, higher

241 RR parents did not show this decrease in passive JA (interaction of condition and RR:

242 $\beta = 0.63$, 89% CI = $[0.22, 1.03]$, $pd = 0.99$). Parents with higher education also showed a

243 lower rate of passive JA episodes $(\beta = -0.25$, 89% CI = $[-0.46, -0.05]$, $pd = 0.97$). Finally,

244 parents with male children made bids for JA at a higher rate (mean: 2.76 bids/min) than

245 those with female children (mean: 2.49, $\beta = 0.81$, 89% CI = $[0.07, 1.57]$, $pd = 0.96$).

246 To get a better sense of the intervention's effect on language use, we analyzed which

247 words were characteristic of parents' speech in each condition, comparing the difference in

248 frequency rank of each word (lemma) in the two conditions, as well as contrasting the

249 corpus overall with a general English-language word frequency list (see SI for the

250 interactive corpus characteristic plot). Words that were strongly indicative of being from

251 the Activity Video condition include "give", "big", "small", "ribbit", "thank", "have", and

252 "bus", while words that were most characteristic of the No Video condition include

253 "shake", "ready", "oh", "on", "going", "going", "see", "let", and the child's name.
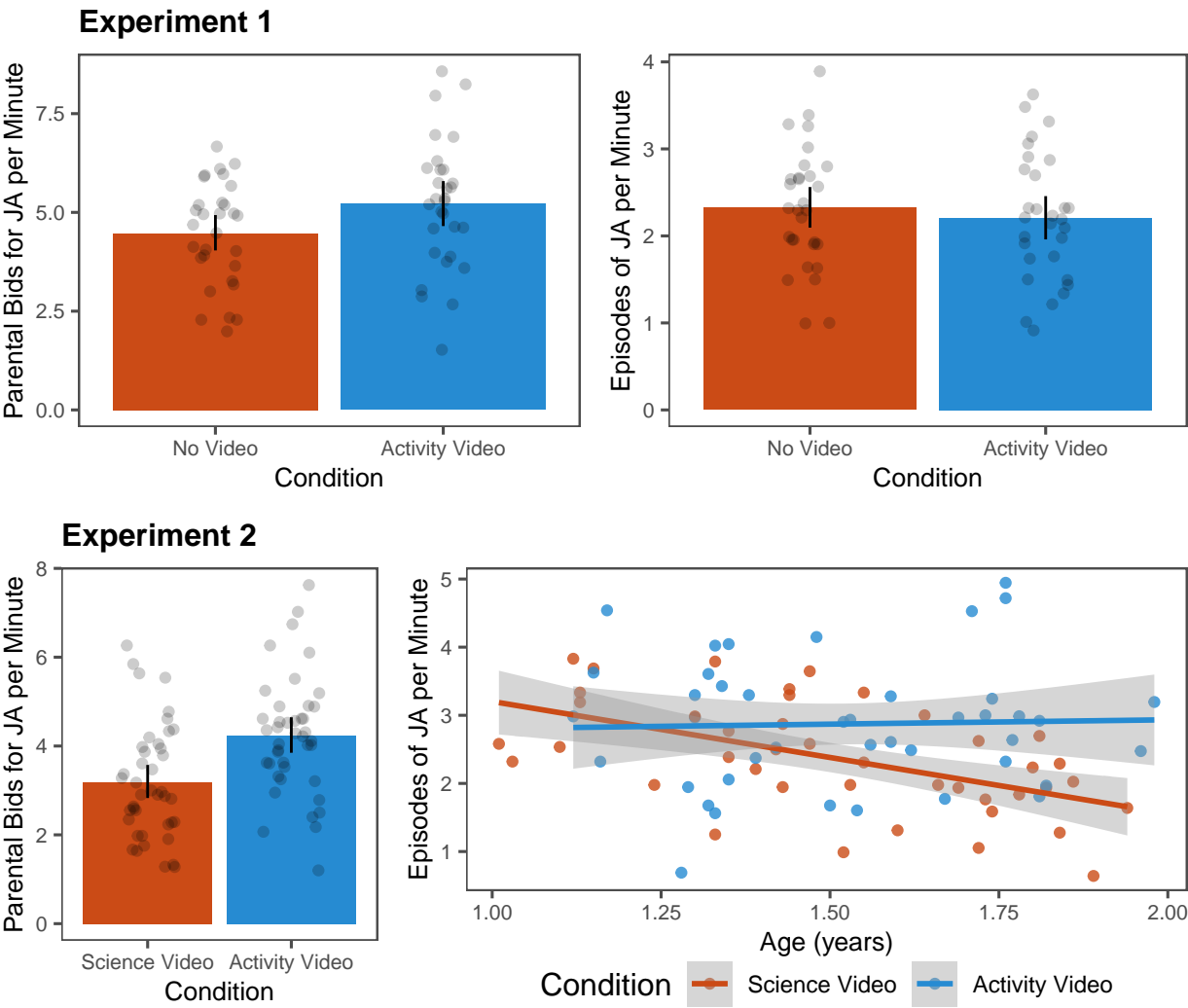

Figure 2.   Mean number of bids (left) and episodes (right) of joint attention (JA) by condition in Experiment 1 (top). For Experiment 2 (bottom), mean number of bids for JA by condition (left) and the number of episodes of JA by age and condition (right).

254   **Discussion.**   In summary, while parents produced more word types and tokens after

255 viewing the activity video, lexical diversity (both TTR and MTLD) was higher when

256 parents were just asked to play as they normally would. It may be that parents in the

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257 Activity Video condition, in their attempt to stick to the prescribed task, end up repeating

258 themselves more, and indeed some differences in speech acts were notable: after the

259 Activity Video, parents used more words related to requests (e.g., "Can I have X? / Give

260 me X. Thank you!"), whereas after no intervention parents' language related more to

261 invitations (e.g., "Are you ready?" / "Let's see."). However, parents who watched an

262 activity video also made more bids for JA with their child. This did not result in a greater

263 number of successful episodes of JA—passive or coordinated—than dyads in the No Video

264 condition, although low reliability in passive JA coding (which led us to refine our JA

265 coding guidelines for Experiment 2) may limit our ability to detect an effect there. In sum,

266 the results of Experiment 1 suggest that digital parenting advice can increase parents'

267 efforts to engage their child in joint attention, expand the volume if not diversity of their

268 speech, and can shift the type of speech acts towards more requests.

Experiment 2

270   Experiment 1 found that parents who watched an activity video made more bids for

271 joint attention and spoke more words tokens per minute to their children, but had lower

272 lexical diversity compared to parents who played with their children as they normally

273 would at home. Might it be that parents who are focused on a specific activity show

274 reduced lexical diversity due to their focus on engaging their child in the activity?

275 Experiment 2 focuses on replicating the key findings using a stronger control group, as well

276 as a restricted number of preregistered predictions.[5]

Method

278   **Participants.**   84 infants (F = 36, M = 46) aged 12-24 months (20 12-17.9

279 month-olds in the Activity Video condition; 21 12-17.9 month-olds in the Science Video

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[5] Preregistration: https://osf.io/6k9m8/.

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280 condition; 22 18-24 month-olds in the Activity Video condition; 21 18-24 month-olds in the

281 Science Video condition) and their parents participated in the same museum as Experiment

282 1. We included infants who were exposed to English at least 75 percent of the time or who

283 were exposed less but whose participating parent reported that they primarily speak

284 English with their child at home. Forty-nine percent of participants (n = 41) had been

285 exposed to two or more languages as indicated by their parent. Parents identified their

286 children as White (n = 39), Asian (n = 20), African American/Black (n = 1), Biracial (n

287 = 9), other (n = 7), or declined to state (n = 8). Sixteen parents reported their child was

288 of Hispanic origin. Parents tended to be highly-educated, with reports of highest level of

289 education ranging from some college (n = 5), four-year college (n = 28), some graduate

290 school (n = 2), to completed graduate school (n = 36) or declined to state (n = 13).

291 **Materials.**   The design of Experiment 2 was similar to that of Experiment 1, except

292 that instead of seeing no video in the control condition, parents instead watched a video

293 that was generally related to child development research, but did not give any specific

294 instructions about how to interact with infants or children. This condition was included to

295 control for the possibility that differences in language output and joint attention in

296 Experiment 1 could be due to simply cueing parents to think about infants' learning and

297 cognitive development. The videos presented in the Control Video condition were media

298 clips (available on YouTube) of developmental psychologists explaining their research

299 interleaved with footage of infants or toddlers engaged in developmental research studies.

300 Thus, the content of the videos superficially matched those in the Activity Video condition,

301 but did not suggest any particular activities. The videos were trimmed to approximately

302 match the average video length in the Activity Video condition (close to 90 s). Details of

303 the videos used in the Activity Video conditions are in the Appendix.

304 **Procedure.**   The procedure for Experiment 2 matched that of Experiment 1, except

305 that parents in the Control Video condition watched a control video before the play

306 session. Consistent with the No-Video control condition in Experiment 1, parents in the

307 Control Video condition were told to play with their child as they would at home, and were

308 not given additional instructions. The coding procedure also matched that of Experiment

309 1. To establish reliability a second coder independently coded 25 of the 84 videos,

310 approximately equally distributed across ages. The two coders had a reliability of ICC =

311 0.81 with 95% confidence interval (CI) = [0.62,0.91] for number of parent bids for JA; ICC

312 = 0.74 with 95% CI = [0.48, 0.88] for number of passive JA episodes; ICC = 0.80 with 95%

313 CI = [0.61, 0.91] for number of coordinated JA episodes; ICC = 0.72 with 95% CI = [0.44,

314 0.86] for time spent (secs/min) in passive JA episodes, and ICC = 0.88 with 95% CI =

315 [0.75, 0.94] for time spent in coordinated JA episodes.

316 **Results**

317 Parents' child-directed speech during the play sessions (mean duration: 3.08 min) was

318 transcribed and processed, and bids and episodes of joint attention were coded according

319 to the same procedure used in Experiment 1. We first report preregistered regressions[6]

320 predicting TTR and rate of word tokens, as well as an exploratory regression predicting

321 MTLD. We then turn to preregistered regressions of parental bids for joint attention and

322 the total number of JA episodes.

323 **Lexical Diversity.**   We fit a Bayesian mixed-effects linear regression predicting

324 TTR as a function of age (centered) and condition with an interaction term, and with

325 random intercepts per video. This revealed lower TTR after the Activity Video (mean:

326 0.38) than after the Science Video (mean: 0.48, $\beta = -0.09$, , 89% CI = [-0.14, -0.04], $pd =$

327 1). The preregistered regression predicting the number of tokens used by parents revealed

328 no effects. An exploratory mixed-effects linear regression predicting MTLD found no effect

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[6] Although the preregistration implied the use of standard linear mixed-effects regression through the specification of adopting an alpha level of .005 for statistical significance, the non-convergence of some regressions led us to switch to Bayesian regression. Using a Bayesian analysis has the added benefit of not requiring arbitrary changes to alpha levels to correct for multiple comparisons (Gelman, 2008).

Table 1

Mean lexical diversity measures in Experiment 2.

Condition	TTR	(sd)	MTLD	(sd)	Types	(sd)	Tokens	(sd)
Science Video	0.48	0.08	22.45	10.57	28.05	8.54	61.85	23.58
Activity Video	0.38	0.12	20.63	8.66	26.57	8.39	77.22	32.09

329 of age or condition. Figure 1 (bottom left and middle) shows the mean of each lexical

330 diversity measure (TTR and MTLD) by condition. Regressions with the same structure

331 predicting the number of words tokens found no effect of age or condition. The means of

332 the lexical measures are shown in Table 1.

333 **Joint Attention.** We fit Bayesian mixed-effects linear regressions predicting the

334 rate of parental bids for joint attention and the rate of JA episodes as a function of fixed

335 effects of condition, age (centered), and their interaction, with random intercepts per video.

336 Shown in Figure 2 (left bottom), parents made bids for JA at a greater rate after watching

337 the Activity Video (mean: 4.23, 95% conf. int.: [3.85, 4.65]; $\beta = 1.04$, 89% CI = [0.54,

338 1.56], $pd = 1$) than after the Science Video (mean: 3.19, 95% conf. int.: [2.83, 3.57]).

339 There were no other effects on parental bids for JA.

340 The regression predicting rate of JA episodes revealed an effect of condition

341 ($\beta = 0.51$, 89% CI = [0.18, 0.85], $pd = 0.99$), with JA episodes occurring at a greater rate

342 after the Activity Video (mean: 2.88, 95% conf. int.: [2.61, 3.17]) than after the Control

343 Video (mean: 2.36, 95% conf. int.: [2.12, 2.60]). Older children also participated in JA

344 episodes at a lesser rate than younger children ($\beta = -1.56$, 89% CI = [-2.42, -0.69], $pd =$

345 1). However, this age effect was moderated in the Activity Video condition ($\beta = 1.70$, 89%

346 CI = [0.28, 3.04], $pd = 0.97$): shown in Figure 2 (right bottom), older children did not

347 engage in episodes of JA at a lower rate after an activity video.

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348   **Exploratory Analyses.**   Four additional exploratory regressions with a similar

349   structure were carried out to predict the number and duration of coordinated and passive

350   JA episodes. The regression predicting the rate of coordinated JA episodes found an effect

351   of condition ($\beta = 0.46$, 89% CI = [0.14, 0.79], $pd = 0.99$), with a greater rate of coordinated

352   JA episodes occurring after the Activity Video (mean: 2.19, 95% CI: [1.93, 2.46]) than

353   after the Control Video (mean: 1.72, 95% CI: [1.52, 1.93]). There was an interaction of age

354   and condition ($\beta = 1.60$, 89% CI = [0.41, 2.92], $pd = 0.98$), shown in Figure 3, revealing

355   that after an Activity Video older children participated in coordinated JA episodes at a

356   greater rate than children in the Control Video condition. The regression predicting the

357   time spent in coordinated JA episodes found no notable effects. Older children both

358   engaged in episodes of passive JA at a greater rate with their caregiver ($\beta = -0.88$, 89% CI

359   = [-1.49, -0.22], $pd = 0.98$), and spent more time in passive JA with their caregiver

360   ($\beta = -5.95$, 89% CI = [-9.86, -1.79], $pd = 0.99$). Overall, these results show that the older

361   children in our sample engage in more and longer episodes of joint attention with their

362   caregivers, and that activity videos in particular lead to more episodes of coordinated JA.

363   As for Experiment 1, we conducted a corpus characteristic analysis to examine

364   differences parents' language use in the two conditions (see SI). The words that were

365   strongly indicative of being from the Activity Video condition include "big", "little",

366   "give", "small", "cow", "yellow", "take", and "put", while words that were most

367   characteristic of the Science Video condition include "beep", "like", "neigh", "uh-oh",
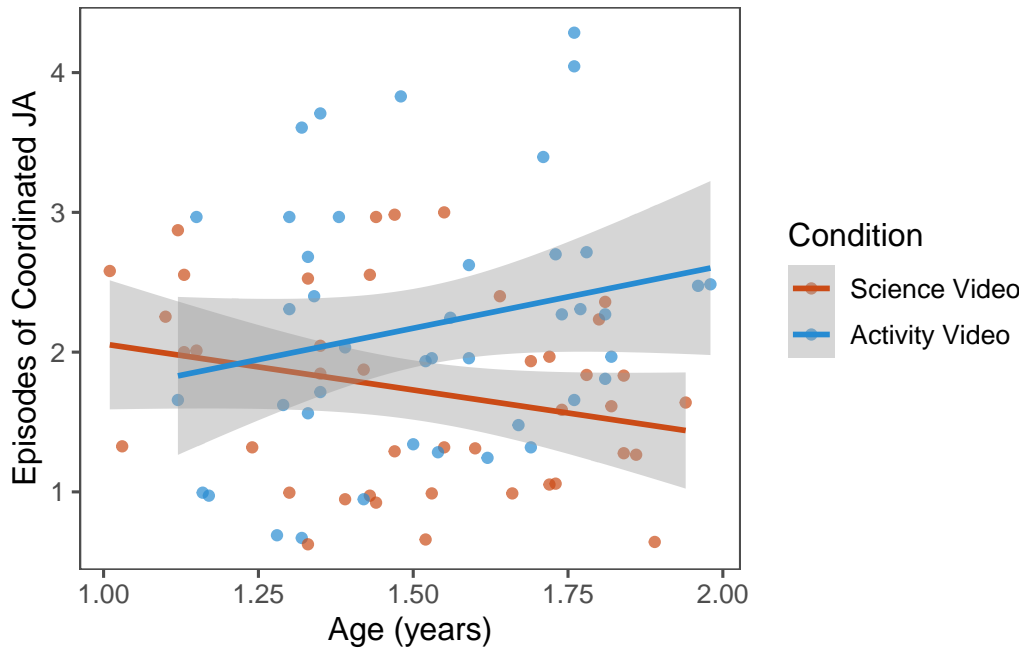
368   "say", "for", "does", and "did".

Figure 3. The number of episodes of coordinated JA by condition and age in Experiment 2.

General Discussion

370   We were interested in how digital parenting advice alters parents' interactions with

371 their children. We specifically set out to test whether activity suggestions led to

372 higher-quality play, a presupposition of many early parenting interventions. Our

373 experiments explored this question by randomly assigning parents to different advice

374 conditions and then observing their behavior in short free-play sessions, with quality of

375 play assessed through measures of parent language and joint attention. In two experiments,

376 we found that activity videos increased the rate of parents' bids for joint attention as

377 compared with no video (Experiment 1) and a comparable science video (Experiment 2).

378 In some cases—especially in older children—these bids were successful in increasing

379 engagement. We also observed differences in parents' talk that were broadly similar across

380 both experiments, with a greater quantity of language but a similar breadth of vocabulary

381 (leading to lower measures of lexical diversity). Exploratory corpus analysis identified the

382 words most characteristic of the activity videos as being related to requests (e.g., "give",

383 "put", "take") whereas control conditions featured more invitational words (e.g., "say",

384 "let", "like"), often asking about animal noises ("What does the X say?").

385   The short, activity-oriented parenting messages we used encouraged parents to make

386 more attempts—both verbal and non-verbal—to engage their child, supporting their use as

387 a component of interventions. Why were they successful? When parents are asked to play

388 with their children in the presence of new toys, they may choose to follow their child's lead

389 and engage in free play. While free play is positive, it nevertheless results in less scaffolded

390 activity than when parents are given a goal that suggests a repertoire of ways to guide

391 their child. Parents may also persist in providing opportunities for their child to complete

392 the activity, leading to more repetitive language but also more offers of engagement.

393   Our study has a number of limitations related to design and sample, each of which

394 suggests possible future directions. First, our design was intentionally short and minimal;

395 future studies should investigate whether changes in parents' speech and attempts to

396 engage their children could persist across a longer timespan (perhaps with a broader set of

397 activities being provisioned). A longer-term study would also address whether consistent

398 increases in parent bids would lead children to respond by engaging more with their parent.

399 Second, our design assumes that parents have access to the materials needed to complete

400 the suggested activities; this assumption may be unrealistic for any parent, but especially

401 for the parents who are most likely to be targeted for early parenting interventions.

402 Providing materials may be critical for the success of activity suggestions. Finally, our

403 sample is a convenience sample drawn from a museum, but it skews towards higher

404 socio-economic status households as well as those families who are well-disposed towards

405 visiting a museum (perhaps because they value education) and are interested in

406 participating in research. A key goal for future research is to assess the generality of these

407 findings across populations.

408   In sum, the results of this study show that digital parenting videos recommending

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409 play activities can lead to short-term increases in parents' attempts to engage their young

410 children, both verbally and non-verbally.

Acknowledgements

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