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**Does SES affect pronoun comprehension and prediction in implicit causality  
scenarios?**

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This paper examines whether individuals' pronoun resolution varies with respect to their socioeconomic status (SES). It uses the data from the Johnson and Arnold (2021) paper to determine whether the author recognition task (ART) effect that was found could instead be explained by participants' SES. Both socioeconomic status (Hecht & Close, 2002; Hoff, 2003; Peterson & Pennington, 2015; Cheng & Wu, 2017) and the author recognition task have been shown to correlate with measures of reading skill, so as a secondary analysis, SES was included as a possible predictor of individual differences.

While measuring SES is complex, the literature suggests that the most commonly used measures are Parental Education, Income, and Social Standing (e.g., Goodman et al., 2001). We therefore probed SES using three measures, as shown in Table 1. Each metric was converted to a z score and averaged to create a single composite SES measure.

**Table 1. SES measures.**

1. **Social Standing.** (Ladder; Keith Payne, personal communication). Think of this below as rungs of a ladder representing where people stand in society. At the top of the ladder are the people that are the best off -- Individuals/families who have the most money, the most education, and the most respected jobs. At the bottom of the ladder are the people that are the worst off-- Individuals/families who have the least money, least education, and least respected jobs or no job. Where would you place yourself on this ladder (1 being the top and 15 being the bottom)? Select the number which best indicates where you think you stand relative to other individuals.
2. **Income.** To your best knowledge, what is your (or your family's) yearly household income?
3. **Parental Education.** The highest educational rank of these two questions was used to represent parental education for each participant.
  - a. Think about the person who you most closely identify as your mother or mother figure (e.g., grandmother or aunt who raised you, adoptive mother, foster mother, etc.) What is her highest level of formal education?
  - b. Think about the person who you most closely identify as your father or father figure (e.g., grandfather or uncle who raised you, adoptive father, foster father, etc.) What is his highest level of formal education?

The primary question behind this analysis was whether the ART effect could be explained by SES. This might be the case if ART and SES are highly correlated such that people with high print exposure also tend to have high socioeconomic status.

### **Analytical approach.**

We ran a mixed-effects logistic regression using SAS proc glimmix with a binary distribution and a logit link. The dependent measure was whether the participant selected the grammatical subject as the referent of the pronoun or not. It was coded as a binary measure with 1 for a grammatical subject selection and 0 for no grammatical subject selection. Predictors included verb bias which was a binary predictor (1 = subject-biased; 0 object-biased), ART scores, which were grand-mean centered, and a composite measure of SES, which was composed of an average z-score calculated from three measures (income, subjective measure of relative social standing, and parental education). Participant and item were included as random intercepts for all models. Random slopes of verb bias were included by participant and item, and random slopes of ART and SES were included by item.<sup>1</sup>

### **Results.**

***Correlations.*** We first tested whether ART was correlated with our composite SES metric in each experiment. As a further exploratory analysis, we also tested whether it correlated with each of the component measures, (see table 2). As Table 2 shows, the SES composite measure and ART were negatively correlated in all three experiments (but only significantly in Exp. 1), which is not what we would predict based on the literature (Hecht & Close, 2002; Hoff, 2003; Peterson & Pennington, 2015; Cheng & Wu, 2017). When we examined each measure

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<sup>1</sup> The ART slope by items was removed from the models in the additional analyses for Exp. 2 because they would not converge.

separately, the only correlations observed were negative correlations between ART and income for Exps. 1 and 2.

**Table 2.** Experiment 1 Correlations

	<b>Exp. 1</b>	<b>Exp. 2</b>	<b>Exp. 3</b>
<b>ART x Composite SES metric</b>	r = -.266 p = .039	r = -.235 p = .070	r = -.144 p = .270
<b>ART x Parental Education</b>	r = .012 p = .925	r = -.178 p = .172	r = -.0859 p = .514
<b>ART x Ladder</b>	r = -.205 p = .115	r = .009 p = .944	r = -.094 p = .474
<b>ART x Income</b>	r = -.363 p = .004	r = -.285 p = .026	r = -.134 p = .306

**Composite SES effects.** Our next question was whether the composite SES measure affected responses. In short, there were no significant effects or interactions with SES for any experiment and results showed that the ART and verb bias interaction remained significant even in the presence of SES, (see tables 3, 4 and 5). In experiment 1 there was a marginal interaction between Verb bias and SES, but the ART effect remained significant even in the presence of this interaction. Therefore, we conclude that the ART effects found in this study cannot be explained by SES.

**Table 3.** Statistical model for SES effect and interaction in Experiment 1

<b>Model Parameters</b>	<b>SES and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.924	0.333	8.76	<.0001
<b>SES</b>	-0.292	0.225	-1.3	0.1985
<b>ART</b>	0.001	0.014	0.09	0.9324
<b>Verb Bias*ART</b>	0.078	0.026	2.94	0.0044
<b>Verb Bias*SES</b>	-0.825	0.429	-1.92	0.0599

**Table 4.** Statistical model for SES effect and interaction in Experiment 2

<b>Model Parameters</b>	<b>SES and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	4.138	0.393	10.52	<.0001
<b>SES</b>	-0.378	0.243	-1.55	0.1403
<b>ART</b>	-0.001	0.012	-0.07	0.9409
<b>Verb Bias*ART</b>	0.102	0.03	3.38	0.001
<b>Verb Bias*SES</b>	-0.281	0.530	-0.53	0.5976

**Table 5.** Statistical model for SES effect and interaction in Experiment 3

<b>Model Parameters</b>	<b>SES and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.891	0.32	9.05	<.0001
<b>SES</b>	-0.322	0.302	-1.07	0.2921
<b>ART</b>	-3.86E-06	0.014	0	0.9998
<b>Verb Bias*ART</b>	0.051	0.023	2.26	0.0277
<b>Verb Bias*SES</b>	0.441	0.482	0.92	0.3629

*Additional Analyses.* To explore the possibility that one measure might better explain our findings than a composite measure of SES, we ran new models that included each SES measure together with ART. We did not perform Bonferroni corrections for these models, because the purpose was exploratory. Therefore any significant effects must be treated with caution, but these models are useful to demonstrate which predictors are unrelated to the dependent measure.

As shown in Tables 6-14, all models revealed the same critical verb bias x ART effect that we reported in the paper. There were no significant effects or interactions with any of the SES measures, except for one: parental education interacted with verb bias for experiment 3, and marginally for experiment 1. However, for experiment 1 the marginal interaction was the

opposite direction than we would expect, i.e. negative. That is, participants with more educated parents show a lower sensitivity to verb type than participants with less education parents. For experiment 3 the interaction was in the expected direction, such that participants with more educated parents showed a higher sensitivity to verb type. However, parental education is completely uncorrelated with ART scores, and the interaction between ART and verb type remained significant in the presence of parental education. In sum, there is no evidence that parental education or any other single measure is likely to explain the ART effect.

**Table 6.** Statistical model for PE and ART effect and interactions in Experiment 1

<b>Model Parameters</b>	<b>Parental Education and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.916	0.331	8.8	<.0001
<b>Parental Education</b>	-0.101	0.136	-0.74	0.4613
<b>ART</b>	0.005	0.013	0.42	0.6753
<b>Verb Bias*ART</b>	0.089	0.025	3.5	0.0008
<b>Verb Bias* Parental Education</b>	-0.498	0.261	-1.91	0.0605

**Table 7.** Statistical model for PE and ART effect and interactions in Experiment 2

<b>Model Parameters</b>	<b>Parental Education and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	4.071	0.382	10.64	<.0001
<b>Parental Education</b>	-0.202	0.166	-1.22	0.2607
<b>ART</b>	0.002	0.012	0.2	0.8441
<b>Verb Bias*ART</b>	0.106	0.030	3.52	0.0007
<b>Verb Bias* Parental Education</b>	-0.326	0.329	-0.99	0.3248

**Table 8.** Statistical model PE and ART effect and interactions in Experiment 3

<b>Model Parameters</b>	<b>Parental Education and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.879	0.311	9.25	<.0001
<b>Parental Education</b>	0.073	0.185	0.39	0.6968
<b>ART</b>	0.003	0.014	0.18	0.8574
<b>Verb Bias*ART</b>	0.055	0.022	2.45	0.0171
<b>Verb Bias* Parental Education</b>	0.619	0.295	2.1	0.0396

**Table 9.** Statistical model Income and ART effect and interactions in Experiment 1

<b>Model Parameters</b>	<b>Income and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.927	0.336	8.72	<.0001
<b>Income</b>	-0.028	0.041	-0.68	0.5008
<b>ART</b>	0.002	0.014	0.17	0.8686
<b>Verb Bias*ART</b>	0.078	0.028	2.81	0.0065
<b>Verb Bias* Income</b>	-0.111	0.078	-1.42	0.1617

**Table 10.** Statistical model Income and ART effect and interactions in Experiment 2

<b>Model Parameters</b>	<b>Income and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	4.126	0.391	10.54	<.0001
<b>Income</b>	-0.011	0.030	-0.36	0.7175
<b>ART</b>	0.001	0.014	0.11	0.9154
<b>Verb Bias*ART</b>	0.101	0.031	3.28	0.0014
<b>Verb Bias* Income</b>	-0.033	0.074	-0.44	0.6625

**Table 11.** Statistical model Income and ART effect and interactions in Experiment 3

<b>Model Parameters</b>	<b>Income and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>

<b>Verb Bias</b>	2.886	0.325	8.88	<.0001
<b>Income</b>	-0.174	0.120	-1.45	0.1506
<b>ART</b>	-0.000	0.013	-0.02	0.9815
<b>Verb Bias*ART</b>	0.047	0.023	2.07	0.043
<b>Verb Bias* Income</b>	0.079	0.214	0.37	0.713

**Table 12.** Statistical model Ladder and ART effect and interactions in Experiment 1

<b>Model Parameters</b>	<b>Ladder and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	2.920	0.339	8.62	<.0001
<b>Ladder</b>	-0.062	0.052	-1.21	0.2379
<b>ART</b>	0.002	0.014	0.16	0.8732
<b>Verb Bias*ART</b>	0.088	0.027	3.29	0.0016
<b>Verb Bias* Ladder</b>	-0.067	0.094	-0.71	0.4783

**Table 13.** Statistical model Ladder and ART effect and interactions in Experiment 2

<b>Model Parameters</b>	<b>Ladder and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>
<b>Verb Bias</b>	4.169	0.396	-3.53	0.0024
<b>Ladder</b>	-0.078	0.052	-1.48	0.1556
<b>ART</b>	0.003	0.013	0.25	0.8032
<b>Verb Bias*ART</b>	0.105	0.029	3.55	0.0006
<b>Verb Bias* Ladder</b>	0.048	0.119	0.4	0.6883

**Table 14.** Statistical model Ladder and ART effect and interactions in Experiment 3

<b>Model Parameters</b>	<b>Ladder and ART Effect</b>			
	Estimate	<i>SE</i>	<i>t</i>	<i>p</i>

<b>Verb Bias</b>	2.863	0.319	8.97	<.0001
<b>Ladder</b>	-0.071	0.067	-1.06	0.2972
<b>ART</b>	0.001	0.014	0.07	0.9457
<b>Verb Bias*ART</b>	0.047	0.023	2.09	0.0414
<b>Verb Bias* Ladder</b>	-0.014	0.109	-0.13	0.8962

## Conclusion.

There is no evidence that socioeconomic status measures can explain the observed correlation between the Author Recognition Task (ART) and pronoun comprehension (Exps 1 and 2) or the observed correlation between ART and prediction (Exp. 3). First, there were no significant positive correlations between ART scores and the SES metrics. Second, we tested whether the response measures correlated with a single composite metric of SES for each participant or with an interaction between SES and verb bias. We found no effects in any experiment, except a marginal interaction in Experiment 1 that went in the opposite direction of what would be expected (i.e., there was a trend for people with higher SES scores to be **less** sensitive to the implicit causality bias).

We additionally performed several secondary analyses to probe whether there were any indications that one of our three SES measures might be correlated with responses. These analyses must be considered with caution because they are exploratory, and we did not correct the p-value for multiple analyses. We found that the income and ladder predictors were completely unrelated to responses across all three experiments. We did find that there was a positive interaction between parental education and semantic bias, such that those with greater parental education scores also showed stronger semantic bias. However, this effect was only

significant in experiment 3, and again only with uncorrected p values. Additionally, across all three experiments and additional analyses, the ART and verb bias interaction was significant.

## AUTHOR NOTE

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