

How (Not) To Interpret and Report Main Effects and Interactions in Multiple Regression: Why Crawford and Pilanski (2013) Did Not Actually Replicate Lindner and Nosek (2009)

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In their commentary on our study of ideology and political intolerance (Crawford & Pilanski, 2013, hereafter CP), Nosek and Lindner (2013) claim that we replicated the findings of Lindner and Nosek (2009, hereafter LN). Specifically, they claim that (1) we replicated their main effect of ideology on political intolerance, such that conservatives are more intolerant than liberals, (2) we replicated their interaction effect of ideology and target political objective on political intolerance, such that people are more intolerant of their political opponents, and (3) our finding that threat mediates the relationship between ideology and intolerance is similar to their finding that speech agreement mediates the relationship between ideology and speech protection.

In fact, none of these claims are true—they are based on misinterpretations of both our data and their own. Rebutting these claims first requires a brief primer on how to interpret main effects and interactions in multiple regression and then a discussion of how Nosek and Lindner mischaracterize the findings of both LN and CP, claim by claim.

Claim 1: Did Both LN and CP Observe Main Effects of Political Ideology on Intolerance?

In multiple regression, the effects of independent variables are only interpretable as main effects when they are reported *from analyses without the interaction term* (Aiken & West, 1991, pp. 38–39; Judd, McClelland, & Ryan, 2009; Whisman & McClelland, 2005). This requires a two-step analysis: a first step with just the independent variables that assesses main effects and a second step in which the interaction term is added to the model with the main effects. The effects of independent variables in the presence of an interaction term are not interpretable as main effects—instead, they are only the “simple” effects of the independent variable when the other independent variable is exactly equal to zero (Judd et al., 2009; Whisman & McClelland, 2005).

This principle is directly relevant to Nosek and Lindner’s interpretation of their findings and our own because both LN and CP *only report the effects of ideology in the presence of the interaction*

Table 1. Two-Step Regression Analysis on Aggregated Intolerance Measure from Crawford and Pilanski (2013)

	Step 1				Step 2			
	<i>b</i>	<i>SE</i>	<i>B</i>	<i>t</i>	<i>b</i>	<i>SE</i>	<i>B</i>	<i>t</i>
Ideology	-.04	.05	-.06	.69	.28	.07	.43	3.91***
Condition	.13	.17	.06	.80	.12	.15	.06	.76
Ideology X Condition					-.56	.10	-.65	5.86***
R ²				.07				.19
ΔR ²				.01				.18***
Constant				2.55				2.60

*** $p < .001$

term. Thus, the true main effects of ideology on political intolerance *were not actually reported in either LN or CP*.

Nosek and Lindner interpreted the coefficients for ideology reported in each of these articles as main effects. Those coefficients are only the effects of ideology when the other independent variable (speech content in LN; target political objective in CP) is exactly equal to zero. In LN, the 0 value for speech content corresponds to no actual data point because speech content was coded as $-.5$ and $+.5$. Given this coding, the coefficient for ideology that they interpreted as a main effect is not a main effect in the traditional sense of an analysis of variance; instead, it is interpretable as the average of the two slopes (i.e., left-wing and right-wing speech) relating ideology to speech protection (see Whisman & McClelland, 2005).

Nosek and Lindner's misinterpretation of the ideology effects in CP's regression analyses is more serious. In CP, 0 represents the left-wing target condition, and 1 represents the right-wing target condition. In CP, the effect of ideology reported in Table 3 is $b = .20$, $p < .01$. Nosek and Lindner interpreted this as a main effect of ideology on intolerance, such that conservatives are more intolerant than liberals. They are incorrect.

This is the effect of ideology on intolerance only in the left-wing target condition, in which conservatives were more intolerant than liberals. This fact is clearly illustrated if we reverse the coding of the Condition variable so that 0 represents the right-wing target condition and 1 represents the left-wing target condition. When we performed regression analyses with this reversed dummy-coded variable, the effect of ideology in the model with the interaction term now has a *negative* coefficient ($b = -.36$, $p < .001$), showing that liberals were more intolerant than conservatives! Of course, this coefficient represents the relationship between ideology and intolerance only in the right-wing target condition, in which liberals were more intolerant than conservatives. Therefore, the coefficient relating ideology to intolerance reported in CP, a result that Nosek and Lindner claim replicates their "main effect" of ideology on political intolerance, is just the simple slope of ideology in the experimental condition that happened to be arbitrarily coded as 0.

Did CP actually observe a main effect of ideology? No. First, Table 4 reported the bivariate correlation between ideology and intolerance, which was $-.05$. This nonsignificant negative coefficient suggests that opposite LN's conclusion, liberals were slightly more intolerant than conservatives across target conditions. Second, while CP performed both steps of the regression analysis, we only reported Step 2. We now report both steps of the regression analysis on the aggregated target intolerance measure in Table 1.¹ There clearly is no ideology main effect in Step 1. In Step 2, the interaction effect accounted for a sizeable proportion of the variability ($\Delta R^2 = .18$, $p < .001$). Thus,

¹ In CP, we included the covariates of political knowledge and generalized intolerance, but now we exclude them to facilitate the comparison between our data and LN's, which did not include covariates.

contrary to Nosek and Lindner’s claim, CP did not actually replicate LN’s main effect of ideology because CP did not *observe* a main effect of ideology (and never claimed to).

Did LN actually observe main effects of ideology? LN did not report ideology main effects in the traditional sense because they only reported the effects of ideology in models including the interaction term. But did they actually *observe* ideology main effects? We cannot know decisively without analyzing their data, but we suspect that they observed a very weak effect of ideology in Study 1. First, Table 2 (LN, p. 78) reported the bivariate correlation between Politics and Speech Protection in Study 1 as $-.09$, $p < .0001$. This weak correlation suggests that liberals more strongly protected free speech than did conservatives. Second, standardized coefficients in a regression are entirely a function of the zero-order correlations among those variables (Alwin & Hauser, 1975). In LN’s data, the main effects model requires regressing Protection on Politics and Content (without the interaction term). The standardized regression coefficient relating Politics to Protection (in a model also including Content) equals:

$$\beta = \frac{r(\text{politics, protection}) - r(\text{content, politics}) * r(\text{content, protection})}{1 - r(\text{content, politics})^2}$$

Using the correlation coefficients provided in LN’s Table 2, the standardized regression coefficient for Politics is approximately $\beta = -.11$ (allowing for rounding errors due to the reporting of correlations to only two decimal places). Given their large sample size ($N = 2,069$), this coefficient is likely statistically significant. Of course, however, this is a small effect. LN did not report the correlation coefficients for Study 2, so it is impossible to know without analyzing their data whether they actually replicated this weak ideology main effect in Study 2. However, given that the ideology effect reported in their model with the interaction term between Politics and the half-contrast coded Content variable should be close to a traditional main effect (Whisman & McClelland, 2005), their results suggest that they probably observed a similarly weak ideology main effect in Study 2 (LN Table 1, Panel 2).

Claim 2: Did CP Replicate LN’s Ideology X Target Interaction?

Nosek and Lindner (2013; msp. 3) claim that, “The interaction effects [in LN] show that speech tolerance is stronger when the speech content matches the ideology of the participant, same as was observed in CP’s study.” This claim suggests that both LN and CP observed an ideology X target crossover interaction, such that liberals were more intolerant than conservatives of right-wing targets, and conservatives were more intolerant than liberals of left-wing targets (or, that liberals were more intolerant of right-wing than left-wing targets, and conservatives were more intolerant of left-wing than right-wing targets).

However, this claim completely mischaracterizes LN’s actual findings: in both Studies 1 and 2, LN clearly observed *spreading*, not crossover interactions (see their Figure 1, p. 76). Their simple slopes (pp. 75–76 for Study 1; p. 82 for Study 2) show that ideology did not significantly predict intolerance of the right-wing target—it only predicted intolerance of the left-wing target. Moreover, whereas liberals were far more intolerant of the right-wing than left-wing target in Studies 1 and 2, conservatives were either equally tolerant of the two targets (Study 2) or modestly more intolerant of the *right-wing* than left-wing target (Study 1). Therefore, LN’s interaction occurred *entirely* because liberals protected left-wing speech more than right-wing speech, whereas conservatives protected left-wing and right-wing speech equally or nearly so.

In contrast to LN’s spreading interactions, CP observed an actual ideology X target crossover interaction on the aggregated target intolerance measure. Liberals were more intolerant than

conservatives of right-wing targets, and conservatives were more intolerant than liberals of left-wing targets. Moreover, liberals were more intolerant of right-wing than left-wing targets, whereas conservatives were more intolerant of left-wing than right-wing targets (see CP Figure 1). Thus, contrary to Nosek and Lindner's claim, the nature of the interactions observed by LN and CP differ from each other and lead to different conclusions regarding the relationship between ideology and political intolerance.

It is surprising to us that Nosek and Lindner claim that LN's findings suggest "speech tolerance is stronger when the speech content matches the ideology of the participant" (Nosek and Lindner, 2013, msp. 3). First, as noted above, this claim is not supported by their findings regarding conservatives, or for right-wing speech. Second, however, this claim is similar to arguments made by Hentoff (1992) and Will (2002) that both those on the political left and right are intolerant of groups they dislike—*arguments that LN contrast with their own hypotheses and findings*, both in the introduction to their article (LN, p. 70) and in their General Discussion (LN, p. 88). Thus, Nosek and Lindner make the logically incoherent claim that their interaction is the same as our interaction, even though our interaction is consistent with the arguments of Hentoff and Will, arguments with which LN contrast their findings.

Claim 3: Did LN and CP Show Similar Mediator Effects?

Nosek and Lindner claim that CP showed mediator effects similar to those of LN and that our proposed mediators are similar. With respect to the similarity of our mediator effects, there are two problems with their argument. First, in their mediated moderation models, they found persistent effects of ideology, over and above the effects of agreement (LN, pp. 78, 83). As we reported in CP (p. 10 and Figures 2 and 3), the effects of ideology on intolerance of left-wing and right-wing targets were nonsignificant after controlling for threat from those targets.²

Second, Nosek and Lindner's characterization of LN's mediated moderation effect implies that agreement explained why liberals more strongly protected left-wing speech and why conservatives more strongly protected right-wing speech (Nosek & Lindner, msp. 1 and 3). This characterization is misleading because as we noted above, in discussing their spreading interactions, there was no relationship between ideology and speech protection in the right-wing speech condition. Variable B can only mediate the effect of Variable A on Variable C if Variable A has an effect on Variable C (Baron & Kenny, 1986). If A does not affect C, then there is no relationship to be mediated.

Therefore, speech agreement cannot explain why ideology predicted protection of right-wing speech *because ideology did not predict protection of right-wing speech*. Thus, their mediated moderation analyses only showed that speech agreement explained the effect of ideology on protection of left-wing speech, not right-wing speech. Put another way, agreement can explain why liberals more strongly protected left-wing than right-wing speech, but it cannot explain differences in speech protection among conservatives, because there either were no differences in speech protection among conservatives (Study 2) or conservatives more strongly protected left-wing than right-wing speech (Study 1), even though they more strongly agreed with right-wing than left-wing speech (LN, p. 75). In other words, agreement only explains liberals' greater willingness to predict left-wing speech.

In contrast, CP found an actual crossover interaction whereby ideology positively predicted intolerance of left-wing targets and negatively predicted intolerance of right-wing targets, and perceived threat fully mediated this crossover interaction (see CP Figures 2 and 3 and Footnote 2, this

² As recommended by Nosek and Lindner, we performed a mediated moderation analysis using Preacher and Hayes' (2008) INDIRECT macro. This analysis confirmed that perceived threat fully mediated the effect of the ideology X target interaction on political intolerance ($a = -1.20***$; $b = .36***$; $c = -.58***$; $c' = -.14$, $p = .202$; $R^2 = .36$; Lower = $-.63$, Upper = $-.29$).

article). Whereas Nosek and Lindner misinterpreted their own findings to indicate that they had evidence that “speech tolerance is stronger when the speech content matches the ideology of the participant,” CP actually found just that pattern. To characterize CP as “replicating” LN’s mediator effects without further explanation and qualification is unjustified and misleading.

In addition to the empirical differences in the actual meditational results, there are theoretical grounds for rejecting Nosek and Lindner’s claim that LN’s speech agreement mediator and CP’s perceived threat mediator measure the same construct—what they call “liking the speech.” First, our selection of perceived threat as a mediator was based on its theoretical importance to the study of political tolerance (Marcus, Sullivan, Theiss-Morse & Wood, 1995; Stenner, 2005; Sullivan, Marcus, Feldman, & Piereson, 1981). Second, in a well-established model of political tolerance (Marcus et al., 1995; Sullivan et al., 1981), liking of a target is the basis of examining political tolerance, and perceived threat is a *separate and exogenous variable*. Thus, “liking” and “threat” should be treated as separate variables—we know of no theoretical perspectives that treat them as the same variable, and Nosek and Lindner cite none. This appears to be an argument fashioned to justify their claim that we merely replicated their findings. Conflating these variables lacks face validity and empirical and theoretical support.

Recommendations and Conclusions

First, Nosek and Lindner’s misinterpretations may reflect common misunderstandings in reporting and interpreting main and interaction effects in multiple regression. To avoid future misinterpretation or confusion, we recommend that authors report the main effects from models that do not include interaction terms and provide a full report of their findings, including zero-order correlation coefficients among all variables, unstandardized and standardized regression coefficients, and standard errors. Editors should ensure such open reporting, if only in supplementary materials.

Second, it should be clear now that the results of LN and CP diverge sharply from each other. LN’s results suggest that liberals may be slightly more likely than conservatives to protect extreme speech, and this effect is driven mostly by liberals’ substantially greater protection of extreme left-wing than extreme right-wing speech. CP’s findings indicate that political intolerance characterizes both the right *and* left in highly symmetrical patterns: (1) conservatives are more intolerant than liberals of left-wing targets, but liberals are more intolerant than conservatives of right-wing targets; and (2) liberals are more intolerant of right-wing than left-wing targets, and conservatives are more intolerant of left-wing than right-wing targets.

What explains the differences between LN’s and CP’s findings? Extremity of the targets’ political behavior is the most likely explanation. LN examined protection of anti-Arab and anti-American speech, which by their own admission was extreme speech (LN, p. 74). CP examined intolerance of free speech and collective action rights towards groups and individuals advocating for a variety of mainstream political positions. In fact, the forms of political expression studied by CP are so commonplace that they border on the mundane (e.g., demonstrating at a state capitol building; registering voters on college campuses). By focusing on more commonplace and less extreme forms of political expression, the results of CP seem far more applicable to understanding typical forms of political intolerance.

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