Beyond the Aggregate Score: Using Multilevel Modeling to Examine Trajectories of Laboratory-Measured Aggression

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Abstract

Aggression is often measured in the laboratory as an iterative ‘tit-for-tat’ sequence, in which two aggressors repeatedly inflict retaliatory harm upon each other. Aggression researchers typically quantify aggression by aggregating across participants’ aggressive behavior on such iterative encounters. However, this ‘aggregate approach’ cannot capture *trajectories* of aggression across the iterative encounters and needlessly eliminates rich information in the form of within-participant variability. As an alternative approach, I employed multilevel modeling to examine the slope of aggression across the 25-trial Taylor Aggression Paradigm (TAP) as a function of trait physical aggression and experimental provocation. Across two preregistered studies (combined N = 392), participants exhibited a modest decline in aggression. This decline reflected a reciprocal strategy, in which participants responded to an initially-provocative opponent with greater aggression that then decreased over time in order to matched their opponent’s declining levels of aggression. Against predictions, trait physical aggression and experimental provocation did not affect participants’ overall trajectories of aggression. Yet exploratory analyses suggested that participants’ tendency to reciprocate their opponent’s aggression with more aggression was greater at higher levels of trait physical aggression and attenuated among participants who had already been experimentally-provoked by their opponent. These findings (a) illustrate several advantages of a multilevel modeling approach as compared to an aggregate approach to iterative laboratory aggression paradigms, (b) demonstrate that the magnifying effects of trait aggression and experimental provocation on laboratory aggression are stable over brief time-frames, and (c) suggest that modeling the opponent’s behavior on such tasks reveals important information.

***Keywords*:** aggression, multilevel model, trait aggression, retaliation, Taylor Aggression Paradigm

Introduction

Aggression, the act of attempting to harm others against their will, manifests in many forms (Anderson & Bushman, 2002). Some aggression occurs once (e.g., a drunk bar patron sucker-punching a bouncer and running away). Yet aggression is often a repeated exchange between two parties (e.g., a fistfight between two worthy adversaries, an escalating exchange of lawsuits and counter-suits between two business-owners). Such phenotypic complexity makes the measurement of aggressive behavior a complex challenge (Anderson & Bushman, 1997).

Iterative Laboratory Measures of Aggression

Laboratory measures of aggression exist that adopt both the singular and iterative forms of aggression. One-shot aggression measures such as the Hot Sauce Aggression Task and Voodoo Doll Aggression Task give participants a single opportunity to hurt another person (DeWall et al., 2013; Lieberman, Solomon, Greenberg, & McGregor, 1999). Iterative aggression measures such as the Taylor Aggression Paradigm (TAP) give participants multiple opportunities to aggress against a target (Taylor, 1967). In the TAP, participants repeatedly compete against an opponent to win a response-time contest. Interleaved among these competitions are punishments for the loser of each competition, which often take the form of noise blasts or electric shocks, and the intensity and duration of these punishments is set by the participant. Aggregated scores of such harmful punishment settings serve as the TAP's operationalization of aggression. This repeated-measures approach is often employed because multiple assessments of aggression, as opposed to a single measurement, increases reliability and internal-consistency (Bushman & Baumeister, 1998). Further, multiple assessments increase the statistical power of the given measure (Westfall, Kenny, & Judd, 2014).

Simulating A Social Encounter

Many psychological assessments include multiple measurements in order to increase reliability and power, such as questionnaires that aggregate across multiple question-responses. However, iterative measures of aggression such as the TAP differ from other such assessments in that they simulate repeated social encounters. The TAP entails repeated interactions with an opponent and the provocative ‘behavior’ of this opponent can influence participants’ aggressive behavior (Taylor, 1967). For instance, an initially-provocative opponent who becomes increasingly pacific will likely result in a trajectory of aggression that tracks with such provocation due to the human tendency for reciprocal aggression (Anderson & Bushman, 2002). Such trajectories may be of interest to aggression researchers who seek to understand the personality and situational factors that influence how aggression unfolds over time and across repeated encounters.

The Effect of Personality Traits and Provoked States on Trajectories of Aggression

Social behaviors, including aggression, are famously a product of both traits and states (Lewin, 1939). Trait aggression reflects the dispositional tendency to behave in an aggressive manner, which can be sub-divided into physical and verbal forms (Buss & Perry, 1992). Measures of trait physical aggression are reliably-linked to greater physically-aggressive behavior (Bernstein, Richardson, & Hammock, 1987; Webster et al., 2014). Further, interpersonal provocations (e.g., insults) are reliable situational causes of aggression (Anderson & Bushman, 2002). However, most laboratory investigations have not examined how such aggression-inducing traits and states impact *trajectories* of aggression.

As a welcome example of an investigation into the trajectories of laboratory task aggression, Anderson, Buckley, and Carnagey (2008) examined the effect of trait aggression and provocation on the slope of aggression across the TAP. The study found that aggression tended to escalate across the trials of the TAP as the participant and their opponent repeatedly provoked each other to an increasing degree. Further, this escalatory slope was steeper for individuals high in trait aggression. These findings suggest that aggression trajectories across the TAP may exist as a function of trait aggression and provocation from the other participant. Yet Anderson and colleagues (2008) estimated these trajectories by calculating a single slope value for each participant and by categorizing the aggression into ‘early’ (first 10 trials of the TAP) and ‘late’ (last 15 trials of the TAP). These both represent aggregate approaches to estimating trajectories of aggression, in which multiple datapoints are combined into aggregate indices of aggression. Such an aggregate approach can be improved upon by adopting analytic techniques expressly designed to estimate trajectories of nested data across multiple timepoints.

Multilevel Modeling of Aggression Trajectories

Multilevel modeling (MLM) is well-suited to accurately model the intercepts and slopes of nested aggression data and has many advantages to the previously-discussed strategies (Nezlek, 2008, 2011; Raudenbush & Bryk, 2002). Indeed, MLM retains and models both the within-person and between-person variability as it does not require that aggression data is aggregated into intercept or slope indices. Further, MLM does not impose arbitrary, categorical structures on the nested data (e.g., first 10 versus last 15 trials of the TAP). In contrast to univariate and path analytic approaches, MLM allows for the presence of missing datapoints and has fewer statistical assumptions (e.g., homogeneity of variance, sphericity). MLM easily models a large number of timepoints (e.g., the 25 trials of the TAP), when doing so in a path analysis would entail an unwieldly array of variables and paths and unclear inferential criteria. For these reasons, MLM is an ideal analytic framework for examining trajectories of aggression across laboratory paradigms.

Examples of MLM being applied to laboratory aggression paradigms are minimal. Webster and colleagues (2014) employed MLM to examine the effect of trait aggression facets on the intercept of aggression levels across the TAP. However, they did not examine the effect of trait aggression on the *slope* of aggression across the task. The present research sought to do so in order to fill this gap in the literature.

Summary

Two preregistered studies estimated the trajectory of aggression across the TAP and examined the role of trait physical aggression on such trajectories. Both of these studies were part of a larger project on validating the TAP and both studies have been previously-published in Chester and Lasko (in press). Yet these data were not analyzed using a multilevel analytic framework to examine trajectories of aggression across the TAP. In both studies, participants were either experimentally-provoked or not and then completed the TAP and a measure of trait physical aggression. MLM was then used to estimate the slope of aggression across the 25 trials of the TAP and test whether trait physical aggression moderated these aggression slopes. I predicted that individuals who were high in trait physical aggression would exhibit stable trajectories of high aggression across the course of the TAP, whereas individuals with relatively lower trait physical aggression would not exhibited such heightened and stable aggression.

Methods

Open Practices and Research Ethics Statement

All research procedures were approved by a university research ethics committee in accordance with institutional and federal research ethics guidelines and standards. The preregistration plans for both studies are available online (Study 1: https://osf.io/7mr6q/register/5771ca429ad5a1020de2872e; Study 2: https://osf.io/ca237/register/565fb3678c5e4a66b5582f67), as are corresponding data, analysis code, and materials (https://osf.io/a2wft/files/).

Participants

In line with the preregistered plan to recruit at least 160 participants per study, I recruited undergraduate students from an introductory psychology subject pool from a mid-Atlantic university in the United States, ceasing recruitment at the end of the academic year in which each study took place (combined N = 404). Twelve of these participants were missing all TAP data due to the software not recording their responses. Participants missing TAP data were excluded from all subsequent analyses, therefore final participants for Studies 1 and 2 were 392 undergraduates (64.8% female, 33.2% male, 2.0% missing gender data; Age: M = 19.59, SD = 3.61, range: 18-55). Participants’ racial composition was 45.1% White, 19.8% African-American/Black, 18.7% Asian-American, 15.8% Other, 0.3% Native American, and 0.3% declined to respond. The sample was 13.0% Hispanic and 87.0% Non-Hispanic. Participants were compensated with course credit.

Measures

Buss-Perry Aggression Questionnaire. Both studies administered the 29-item Buss-Perry Aggression Questionnaire, which is the most widely-used and well-validated measure of trait aggression (BPAQ; Buss & Perry, 1992; Harris, 1997; Tremblay & Ewart, 2005). The BPAQ possesses a four factor structure subscales measuring each dispositional construct: anger, hostility, physical aggression, and verbal aggression. Participants rated their agreement with various statements about themselves along a 1 (strongly disagree) to 7 (strongly agree) scale. My preregistered predictions focused on the nine-item Physical Aggression subscale of this measure, as this most closely mapped onto the aggression measured by the TAP.

Provocation Manipulation Check. Both studies administered a manipulation check questionnaire that asked participants how much their essay feedback from the provocation manipulation made them feel ‘provoked’, ‘insulted’, ‘angry’, ‘hostile’, ‘offended’, and ‘annoyed’ (akin to Denson, von Hippel, Kemp, & Teo, 2010). Participants made these responses along a 1 (not at all) to 7 (extremely) scale.

Taylor Aggression Paradigm. The version of the TAP used in both studies took the form of the computerized 25-trial Competitive Reaction Time Measure of Aggression v.2.9 (Bushman & Baumeister, 1998). This measure exhibits strong evidence of construct validity (Anderson & Bushman, 1997; Chester & Lasko, in press; Giancola & Parrott, 2008; Giancola & Zeichner, 1995). Participants began each trial by setting the volume (60-105 decibels, in 5 decibel increments) and duration (0 – 5 seconds, in 0.5

second increments) of noise blasts. Participants could also set the volume or duration to 0 to prevent any aggression. Then, participants competed against their opponent (i.e., a fictitious same-sex undergraduate) to press a button as fast as possible. Participants lost 12 and won 13 of the 25 trials in an order that was initially randomized and then held constant across participants, though participants could lose more trials if they failed to respond quickly during the competition). When participants discovered that they had lost a competition, they received a noise blast at the volume and duration that their fictitious opponent set for them. Wins and losses were randomized across trials and held constant across participants. Participants' opponents began the task by selecting the highest noise settings and then became progressively less provocative over the course of the task.

Procedure

In both studies, participants arrived individually to the laboratory, where they read and signed an informed consent form. Participants were given a cover story in which the study was intended to examine their 'cognitive abilities' and their effect on personality. Afterwards, participants were screened for sensitive hearing, due to the TAP's noise blasts. Then, participants completed a provocation paradigm in which participants received harsh or positive feedback on an essay that they wrote, which was introduced as an assessment of one of their cognitive abilities: writing skill (Bushman & Baumeister, 1998; Chester & DeWall, 2017). The essay evaluation contained either negative (8/35 points, "One of the WORST essays I've EVER read!") or positive (33/35 points, "Great essay!") feedback, as determined by random assignment. The experimenter then directed participants to the computer to complete the TAP, describing it as a measure of another cognitive ability: reaction time. The experimenter explained the task to the participant, gave them a sample of a moderately loud noise blast, and then left to check on the fictitious partner's internet connection to the participant. Participants then completed a battery of aggression and other measures that included the BPAQ (un-counterbalanced order in Study 1, counterbalanced order in Study 2), which were introduced to participants as personality measures. Finally, participants were debriefed and completed a post-debriefing questionnaire that assessed suspicion by asking participants to indicate whether they experienced 'total disbelief', 'some doubts', 'small doubts', or 'totally believed it'. Consistent with my preregistration plans, I did not exclude participants based on their self-reported suspicion of deception.

Analytic Plan

Data was combined from both studies to provide a better-powered test of the hypotheses. Due to the strong correlation between duration and volume settings on the TAP, $r(390) = .90$, $p < .001$, these two settings were averaged at each trial of the TAP for each participant. Within-participant variance in trial-by-trial aggressive behavior (i.e., the average of duration and volume settings on each trial of the TAP) was modeled at level 1, in which Aggression_{ti} represents the average noise blast duration and volume at each TAP Trial t by each participant i, π_{0i} *captures each* participant's aggression intercept, π_{1i} *captures each* participant's aggression trajectory, and e_{ti} captures residual error variance:

$$\textbf{Aggression}_{ti} = \pi_{0i} + \pi_{1i}(\textit{Trial}) + e_{ti}$$

Level 2 modeled between-participant variance in the intercept and slope of aggression as a function of trait physical aggression (grand-mean centered) and Study (coded: Study 1 = 1, Study 2 = 2):

$$\textit{Intercept}_{0i} = \beta_{00} + \beta_{01}(\textit{Trait Physical Aggression}) + \beta_{02}(\textit{Study}) + r_{0i}$$

$$\textit{Slope}_{1i} = \beta_{10} + \beta_{11}(\textit{Trait Physical Aggression}) + \beta_{12}(\textit{Study}) + r_{1i}$$

This conditional growth model using MLM was employed using the PROC MIXED function of SAS v.9.4 software using maximum likelihood estimation. The models specified random intercepts and slopes, which was motivated by the empirically-supported assumption that trait physical aggression and experimental provocation would exert heterogeneous effects on different participants' intercepts and slopes (Anderson et al., 2008).

The preregistration plan did not specify the expected structure of the models' covariance matrices or residual structures. As such, I compared model fit statistics for four different covariance and residual matrix structures (Table 1), in which the best fit was obtained for an unstructured covariance matrix and autoregressive residual structure, which was subsequently adopted. Visual inspection of histograms and Q-Q plots of the residuals from each MLM revealed that the analyses met the assumptions of normality of residuals and homoscedasticity. Because an autoregressive residual correlation matrix was adopted, each MLM was not bound by assumption of independence. MLM interactions were then probed using an online utility (http://www.quantpsy.org/interact/hlm2.htm; case 3; Preacher, Curran, & Bauer, 2006).

Table 1. Model fit statistics for different covariance and residual matrix structures. Smaller values indicate relatively better model fit. AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion; AR = Auto-Regressive, UN = Unstructured.

	Trait Physical Aggression		*Experimental Provocation*	
Model	*AIC*	BIC	*AIC*	*BIC*
AR Covariance Matrix	43,273.00	43,300.70	43,888.30	43,916.10
UN Covariance Matrix	41,349.70	41,385.70	41,955.00	41,990.80
AR Covariance Matrix & AR Residual Matrix	40,926.60	40,958.30	41,506.10	41,537.90
UN Covariance Matrix & AR Residual Matrix	40,345.40	40,385.00	40,936.00	40,975.80

Results

Deviations from Preregistration Plan

The present sample sizes were larger than the intended 160 per study and instead of analyzing each study's dataset separately, I combined them into an integrative data analysis (Curran & Hussong, 2009) in order to yield a better powered estimate while still modeling the nested nature of the two studies' data. Further, I used the full Buss-Perry Aggression Questionnaire instead of the Brief Aggression Questionnaire due to concerns over low internal consistency estimates from this briefer version. I was unable to achieve the 50% gender equity that I preregistered and I did not enact the outlier exclusion rule, as this proved to be far too conservative and would have led to the exclusion of a substantial portion of this sample.

Missing Data

Of the final 392 participants, six participants did not complete the BPAQ due to time constraints and 20 participants did not provide Provocation Manipulation Check data due to the measure being incorrectly formatted and thus the affected data was discarded. MLMs that assess the BPAQ and Provocation Manipulation Check excluded participants who were missing data from these respective measures. Of the participants who provided at least some data from the BPAQ and Provocation Manipulation Check, less than 2.5% of responses to either of these self-report measures were missing. As such, imputation was not employed and the remaining responses were simply averaged together to ensure that missing data did not artificially deflate scores on these measures.

Descriptive Statistics and Manipulation Check

Descriptive statistics are presented in Table 2. Across both studies, the 25 trials of the TAP, $\alpha = .97$, the Physical Aggression subscale of the BPAQ, $\alpha = .81$, and the Provocation Manipulation Check, $\alpha = .93$, exhibited sufficient internal consistency. TAP scores from the present studies had similar mean-levels though somewhat more variability than those obtained in other studies (e.g., Velez, Greitemeyer, Whitaker, Ewoldsen, & Bushman, 2016). Participants who were randomly-assigned to receive negative feedback on their essay reported higher scores on the Provocation Manipulation Check than those who received positive essay feedback, $B = 0.84$ [*95% CI* = 0.69, 1.00], $SE = 0.07$, $t(369) = 10.94$, $p < .001$.

Table 2. Descriptive statistics across both studies, provided in aggregate (i.e., Overall) and separately by experimental condition. BPAQ = Buss-Perry Aggression Questionnaire (Physical Aggression subscale), PMC = Provocation Manipulation Check, TAP = Taylor Aggression Paradigm.

	Overall		Provoked		Unprovoked	
Measure	*M*(*SD*)	Range	*M*(*SD*)	Range	*M*(*SD*)	Range
BPAQ	2.73(1.06)	1.00-6.00	2.78(1.05)	1.00-6.00	2.69(1.06)	1.00-5.67
PMC	2.73(1.75)	1.00-7.00	3.59(1.75)	1.00-7.00	1.85(1.25)	1.00-7.00
TAP	4.99(2.09)	0.00-10.00	5.38(2.20)	0.00-10.00	4.59(1.90)	0.00-10.00

Confirmatory Tests

Across participants, aggression exhibited a declining trajectory across the 25 trials of the TAP (Figure 1; Table 3). Aggregating across these trials, trait physical aggression was associated with greater noise blasts on the TAP but did not appear to influence participants' trajectories of aggression (Figure 1; Table 3).

Figure 1. Aggression trajectories across trials of the Taylor Aggression Paradigm (TAP) as a function of trait physical aggression. PA = Physical Aggression.

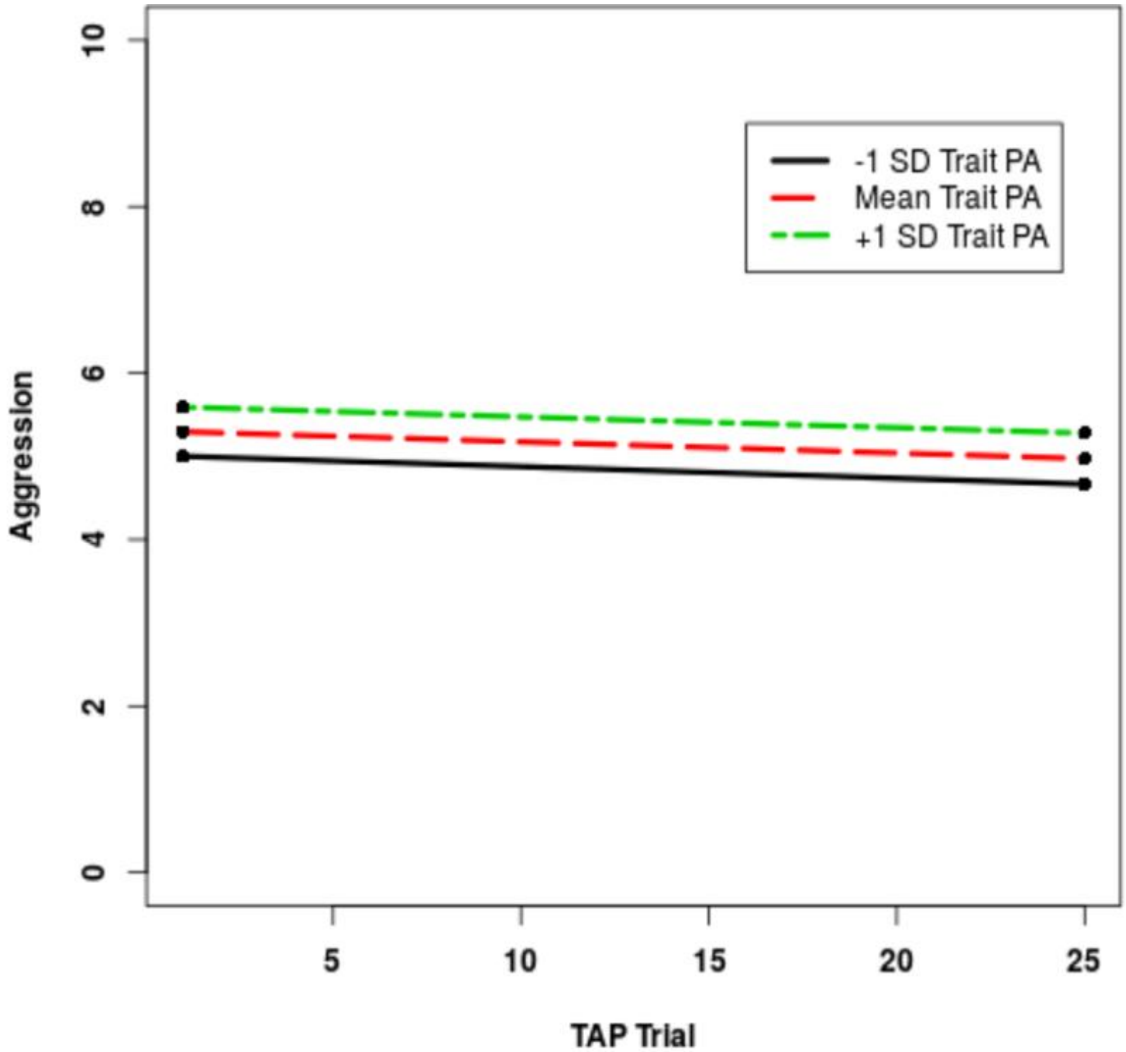

Table 3. Multilevel modeling results for aggressive behavior across the trials of the Taylor Aggression Paradigm, as a function of trait physical aggression. PA = Physical Aggression.

Effect	*B*	95% *CI*	*SE*	*t*	*df*	*p*
Trial	-0.01	-0.02, 0.00	0.01	-2.99	385	.003
Study	-0.11	-0.53, 0.30	0.21	-0.54	386	.589
Trait PA	0.28	0.06, 0.50	0.11	2.54	389	.012
Trait PA x Trial	0.00	-0.01, 0.01	0.01	0.10	385	.918

Simple slopes analysis revealed that the decline in aggression was quite stable across relatively low, mean, and high levels of trait physical aggression (Table 4).

Table 4. Simple slopes of aggression across the trials of the Taylor Aggression Paradigm at relative levels of trait physical aggression. PA = Physical Aggression.

Trait PA Level	*B*	*SE*	*t*	*p*
-1 *SD*	-0.01	0.01	-2.20	.028
Mean	-0.01	0.01	-3.01	.003
+1 *SD*	-0.01	0.01	-2.05	.041

Exploratory Analyses

Effect of provocation. To examine whether the stability of trait effects over the course of the TAP also held for situationally-induced states, I replaced trait physical aggression's role as a moderator of TAP score trajectories with the experimental provocation manipulation that I employed (coded as unprovoked = -1, provoked = 1). Experimental provocation increased noise blasts on the TAP but did not appear to influence participants' trajectories of aggression (Figure 2; Table 5).

Figure 2. Aggression trajectories across trials of the Taylor Aggression Paradigm (TAP) as a function of experimental provocation condition.

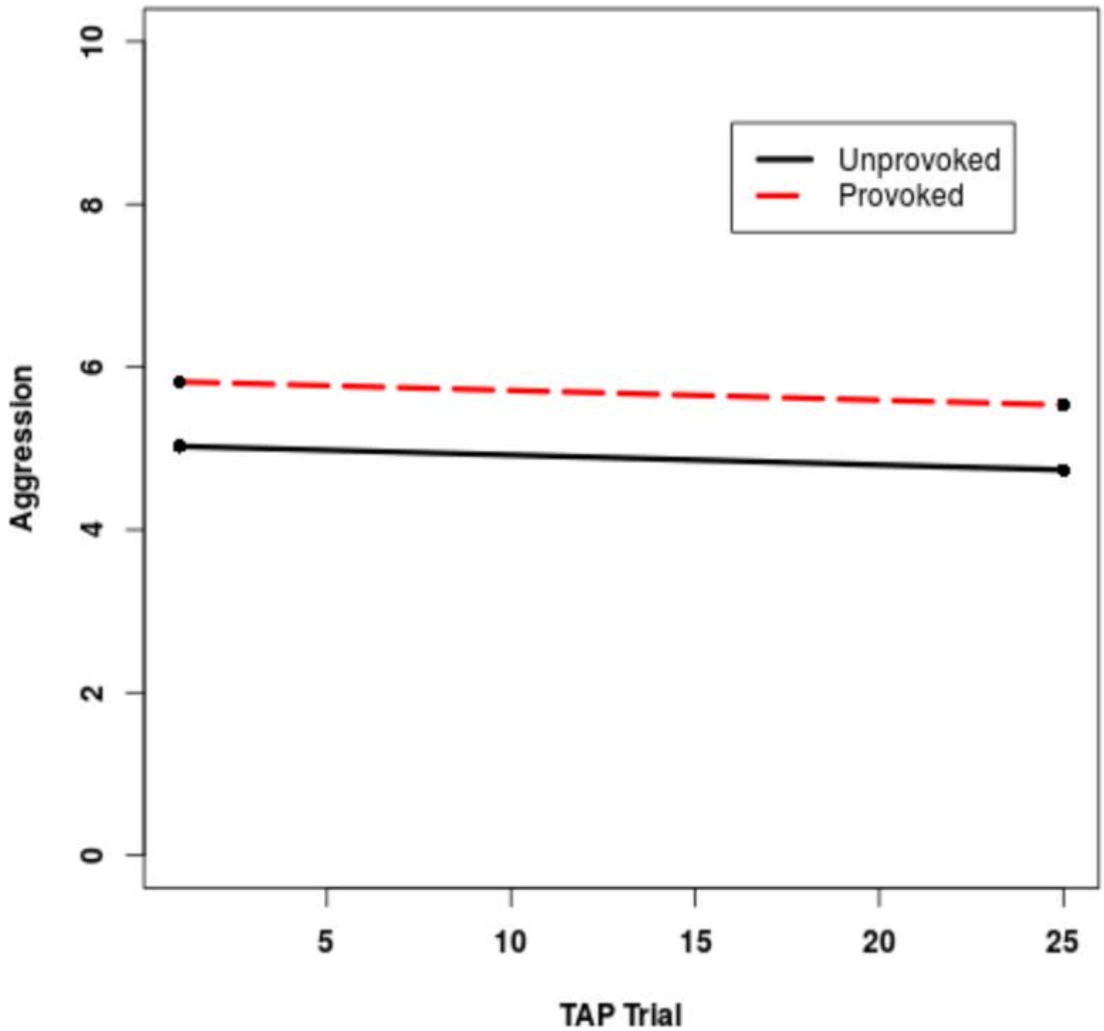

Table 5. Multilevel modeling results for aggressive behavior across the trials of the Taylor Aggression Paradigm, as a function of experimental provocation condition.

Effect	*B*	95% *CI*	*SE*	*t*	*df*	*p*
Trial	-0.01	-0.02, 0.00	0.01	-2.64	391	.009
Study	-0.22	-0.62, 0.19	0.21	-1.05	392	.292
Provocation	0.40	0.17, 0.62	0.11	3.50	392	.001
Provocation x Trial	0.00	-0.01, 0.01	0.01	0.03	391	.978

Simple slopes analysis revealed that the decline in aggression was no longer evidence when unprovoked and provoked conditions were separately examined (Table 6).

Table 6. Simple slopes of aggression across the trials of the TAP for both provocation conditions.

Condition	*B*	*SE*	*t*	*p*
Unprovoked	-0.01	0.01	-1.86	.064
Provoked	-0.01	0.01	-1.85	.066

Modeling opponent's TAP provocation. To examine whether participants exhibited a retributive tit-for-tat strategy, I added the fictitious opponents' provocation settings from the previous trial of the TAP (averaging across duration and volume settings) into the multilevel model, setting the first trial's prior provocation to 0 to model the lack of a previous trial. This model revealed a robust effect of the opponent's previous provocation on greater aggression, though this effect was only marginally moderated by trait physical aggression (Figure 3, Table 7).

Figure 3. Aggression on the Taylor Aggression Paradigm (TAP) as a function of opponent provocation from the previous trial of the TAP and trait physical aggression. PA = Physical Aggression.

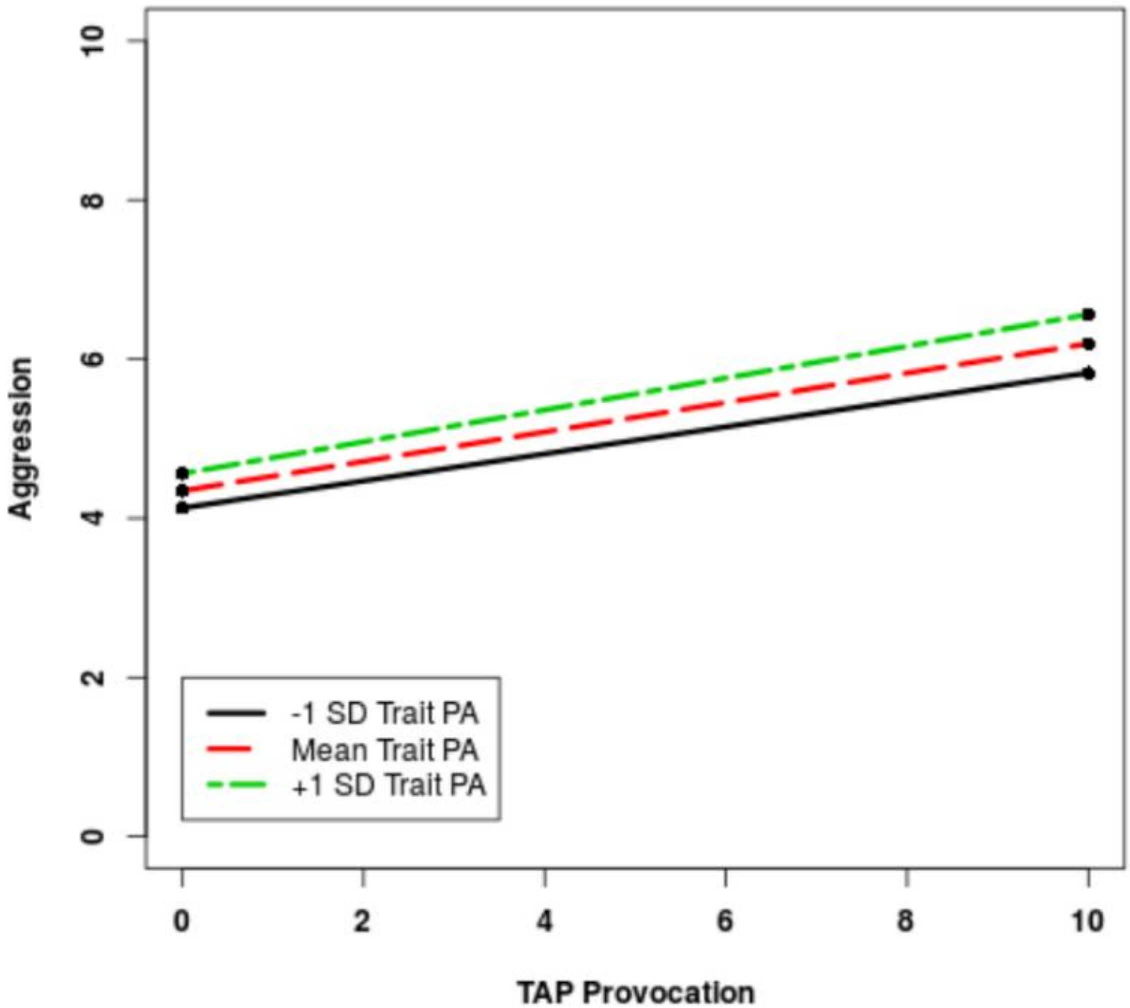

Table 7. Multilevel modeling results for opponent provocation from the Taylor Aggression Paradigm (TAP) and trait physical aggression's effects on aggressive behavior across the trials of the TAP. PA = Physical Aggression.

Effect	*B*	95% *CI*	*SE*	*t*	*df*	*p*
Trial	-0.02	-0.02, -0.01	0.00	-3.33	385	.001
Study	-0.12	-0.53, 0.30	0.21	-0.54	386	.587
TAP Provocation	0.19	0.17, 0.20	0.01	23.03	6,523	< .001
Trait PA	0.20	-0.03, 0.43	0.12	1.74	498	.082
Trait PA x Trial	0.00	-0.01, 0.01	0.00	0.09	385	.932
Trait PA x TAP Provocation	0.01	0.00, 0.03	0.01	1.88	6,522	.060

Simple slopes analysis revealed that the effect of the previous trial's provocation on aggression became progressively larger as levels of trait physical aggression increased (Table 8).

Table 8. Simple slopes of aggression as a function of opponent's provocation from the previous trial of the Taylor Aggression Paradigm at relative levels of trait physical aggression. PA = Physical Aggression.

Trait PA Level	*B*	*SE*	*t*	*p*
-1 *SD*	0.17	0.01	14.91	< .001
Mean	0.19	0.01	22.95	< .001
+1 *SD*	0.20	0.01	17.56	< .001

To examine whether experimentally-manipulated provocation exacerbated the provocation inherent in the TAP, I modeled the experimental provocation manipulation (coded as unprovoked = -1, provoked = 1) as a moderator of this effect. Provocation's effect on greater aggression was smaller on high, relatively to low, provocation trials (Figure 4; Table 9).

Figure 4. Aggression on the Taylor Aggression Paradigm (TAP) as a function of opponent provocation from the previous trial of the TAP and experimental provocation condition.

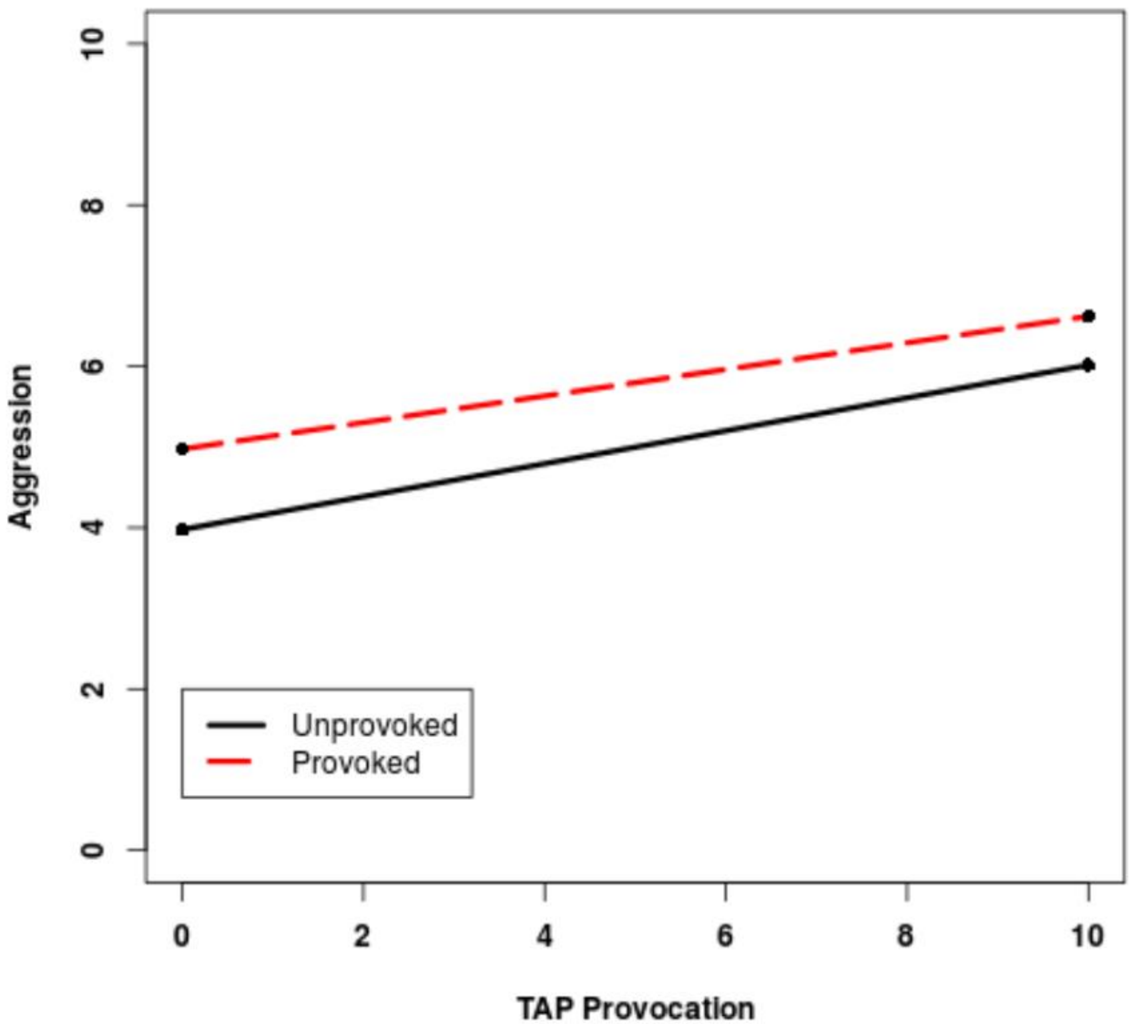

Table 9. Multilevel modeling results aggressive behavior as a function of both opponent provocation from the previous trial of the Taylor Aggression Paradigm (TAP) and experimental provocation condition.

Effect	*B*	95% *CI*	*SE*	*t*	*df*	*p*
Trial	-0.01	-0.02, 0.00	0.00	-2.97	391	.003
Study	-0.22	-0.62, 0.19	0.21	-1.06	392	.290
TAP Provocation	0.18	0.17, 0.20	0.01	23.17	6,612	< .001
Essay Provocation	0.50	0.26, 0.74	0.12	4.13	505	< .001
Essay Provocation x Trial	0.00	-0.01, 0.01	0.00	0.06	391	.954
Essay Provocation x TAP Provocation	-0.02	-0.04, 0.00	0.01	-2.48	6,612	.013

Simple slopes analysis revealed that the effect of opponent provocation from the TAP on greater aggressive behavior was stronger among unprovoked participants (Table 10).

Table 10. Simple slopes of aggression as a function of opponent provocation from the previous trial of the Taylor Aggression Paradigm for both provocation conditions.

Condition	*B*	*SE*	*t*	*p*
Unprovoked	0.20	0.01	18.05	< .001
Provoked	0.16	0.01	14.78	< .001

Discussion

Laboratory aggression measurement must simultaneously contend with threats to internal validity, external validity, and ethical treatment of participants. These demands have produced many clever and sophisticated approaches to quantifying aggressive behavior (e.g., the Taylor Aggression Paradigm [TAP]; Taylor, 1967). The refinement of these important tools is an ongoing process and one that requires investigation from many angles. I attempted to contribute to this psychometric goal by investigating the *trajectory* of aggressive behavior across the TAP as most studies using this paradigm simply aggregate the multiple datapoints obtained from this measure, in one form or another (Hyatt, Chester, Zeichner, & Miller, in press). Further, I sought to demonstrate the added utility of multilevel modeling in analyzing the complexities of multiple-timepoint laboratory paradigms, which is normally confined to more longitudinal measures.

Reciprocal Trajectories of Aggression

Participants' aggression trajectories were strongly-predicted by the provocative behavior of their fictitious opponent. Reflecting the high initial provocation levels of their opponent, participants' aggression began high and then modestly declined across the task as their opponent became less provocative. Further, participants' aggression was strongly predicted by their opponents aggression settings on the immediately preceding trial. This pattern of results reflects a well-known human tendency to reciprocate aggressive behavior and replicates prior work showing this phenomenon in the laboratory (Anderson & Bushman, 2002; Anderson et al., 2008). Such retaliation also provides further evidence for the construct validity of the TAP as any accurate measure of aggression should capture this 'tit-for-tat' strategy.

Trajectories as a Function of Trait Aggression and Experimental Provocation

Seeking to build on these initial findings, I examined the role of dispositional aggressiveness and experimental provocation on aggression. These two variables were chosen given their established links to increasing aggressive behavior on laboratory assessments (Chester & Lasko, in press; Webster et al., 2014). Against my predictions, the overall declining trajectories of aggression across the TAP were unaffected by either trait physical aggression or the experimental essay provocation procedure. These null effects suggest that, although average levels of aggression are reliably affected by these variables, these effects are stable across time and repeated social interactions. The remarkable invariance of these effects supports the use of aggregate scoring approaches, as they do not appear to be occluding any interesting changes over time.

‘Tit-For-Tat’ as a Function of Trait Aggression and Experimental Provocation

When the opponent’s aggression settings from the previous trial were entered into the model, their effect on participants’ aggression was indeed a function of experimental provocation. Indeed, experimentally-unprovoked individuals showed less overall aggression than their provoked counterparts, but as their opponent became more aggressive their aggression rose to meet it faster than their provoked counterparts. This result may simply reflect a ceiling effect, in which provoked participants were already so aggressive that they could not increase their aggression as much as unprovoked participants. Additionally, this finding suggests that higher levels of opponent provocation attenuate the lingering effects of experimental manipulations. Investigators who seek to maximize the influence of experimental provocations will be well served by limiting the aggressiveness of the simulated TAP opponent.

Though the interaction did not achieve statistical significance, there was modest evidence that trait physical aggression also moderated participants' tendency for 'tit-for-tat' reciprocity. At higher levels of trait physical aggressiveness, participants were not only more aggressive in general, but also exhibited a stronger tendency to match their opponent's aggression with more of their own. This finding, while only marginal and exploratory, replicates past work showing that cycles of escalating violence are magnified among individuals who tend to be more aggressive (Anderson et al., 2008). Indeed, an underlying mechanism that reinforces aggressive tendencies to the point that they become trait-like may be the simple impulse to match violence with more violence.

Across both models, these findings support the utility of an MLM analytic framework to not only model aggression across the trials of the task, but to also explicitly model the opponent's behavior. This can be done for studies that use a single, static schedule of opponent provocation or for those that have randomized and dynamic schedules. Instead of relying on separate, between-participant provocation manipulations to examine such effects, MLM allows investigators to examine the effect of trial-by-trial variability in the opponent's level of aggression on the participant.

Using MLM to Advance a Science of Aggression Trajectories

The present research provides unequivocal evidence for the advantages of MLM approaches to analyzing data from iterative laboratory measures of human aggression. MLM is able to accurately and simultaneously estimate both the between-participant variance in mean-levels aggression levels as well as the within-participant variance in trajectories that unfold across the simulated social interaction (Nezlek, 2008, 2011).

Estimating both of these elements and how they function in relation to situational and personal factors is likely to yield valuable insights into aggression that are obfuscated by merely looking at aggregated scores. Aggression researchers could revisit their existing datasets, considering how their key variables of interest might influence *trajectories* of aggression across laboratory tasks, not just their aggregated values. Such data is costly and difficult to collect and MLM gives investigators a tool to extract added informational value from these existing resources. In addition, by avoiding aggregate approaches that combine datapoints into a single index, MLM approaches help to combat the field's issues with low statistical power. Instead of aggregating 50 measurements into a single aggression index, MLM allows investigators to harness the statistical power inherent in the repeated measurements and random factors (Westfall et al., 2014).

Limitations and Future Directions

These results are likely specific to this particular iteration of the TAP's level of provocation from the simulated opponent. A dearth of work has estimated the extent to which different provocation schedules on the TAP ultimately affect participants' aggression levels or interact with specific traits and states. Much more work is needed to compare the validity of the TAP when differing provocation regimens are used. In these future cases, multilevel modeling will be useful to estimate not only to what extent are average aggression levels affected by these provocation-variants, but also to model the different trajectories thereof.

The use of an undergraduate sample for these two studies undermine the generalizability of these findings. As with most undergraduate samples, trait physical aggression was relatively low in this sample, which meant that the relatively higher ends of this sample’s aggressiveness did not qualify as ‘truly aggressive’ individuals. It may be that more antisocial populations (e.g., violent offenders), may exhibit substantially different trajectories of aggressive behavior across the TAP and therefore all inferences from this investigation are applicable only to this population. Our understanding of certain forensic and clinical populations may be greatly advanced by investigating how they differ in aggression trajectories. Indeed, some populations may exhibit nearly-identical mean-level aggression in the laboratory, which may obscure quite divergent trajectories of aggressive behavior. For instance, one population may be slow to become aggressive but much more aggressive after continued provocation whereas another may be quick to aggression but may forgive such provocation and disengage from an aggressive encounter as the task unfolds. These nuanced forms of understanding will only be possible if future work considers aggression trajectories.

Conclusions

Aggression unfolds dynamically over the course of antagonistic interactions. To date, laboratory investigations of aggression have failed to fully capture this complexity. Although these findings suggest that such trajectories are largely insensitive to aggressive traits and states, trial-by-trial reciprocity of aggression was influenced by these variables. These findings suggest that the MLM approach holds promise to uncover hidden nuance in aggressive behavior. Complex problems require complex tools to solve them and research on human aggression is a fertile field on which to apply this principle.

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