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Retributive Impulses in Online Cancel Culture: The Role of Echo Chambers and Individual Differences

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Abstract

This study investigated whether cancel culture is driven by the retributive impulse and the role of echo chambers in online platforms. An anonymous online survey was utilised for this single-factor between-subjects study. Retained participants (*N*=126) aged between 18-79 in Australia read a fictional social media post calling for the cancellation of a university professor with comments on the post being either supportive (echo chamber) or mixed (no echo chamber). As predicted, those in the echo chamber condition showed significantly higher punitive sentiments than those in the no echo chamber condition. Moreover, anger independently predicted punitive sentiment, suggesting the retributive impulse does drive cancelling behaviour. However, contrary to expectations, anger did not mediate the relationship between echo chamber and punitive sentiment, nor did Need for Cognition or Emotional Reactivity moderate this indirect effect. Findings tentatively support that cancel culture may be an expression of the retributive impulse, however, the link between echo chambers and the retributive impulse remains unclear. Future qualitative research is required to elucidate what is driving participation in this complex social phenomenon in conjunction with higher verisimilitude stimuli.

Introduction

In recent years, cancel culture has emerged as a means of online sanctioning by which individuals face collective condemnation and reputational damage for perceived moral or social transgressions (Tegrarian, 2025). Cancel culture is characterised by rapid collective mobilisation, moral outrage amplification, and coordinated demands for severe consequences against perceived wrongdoers by self-appointed arbitrators (Clark, 2020; Ng, 2020; Tegrarian, 2025). This phenomenon came to the fore in 2017 with the #MeToo movement mobilising millions online demanding accountability for alleged sexual misconduct by Harvey Weinstein. Proponents of cancel culture claim that it can be utilised to hold powerful people to account, whereas critics argue that it is a form of mob justice that deals disproportionate punishment (Clark, 2020; Pearson, 2021). Cancel culture can have profound social and psychological consequences for both those engaging in cancelling behaviour and for targets of cancellation (Marinovic et al., 2022). Recent studies have established severe psychological consequences for targeted individuals, elucidating links to post traumatic stress disorder, depression, and anxiety (Aguiar et al., 2025). There are also interpersonal repercussions, as with any form of social ostracisation, and uniquely, financial repercussions for being ‘cancelled’ (Aguiar et al., 2025; Tegrarian, 2025). The importance of understanding this phenomenon also goes far beyond the individual, as it has judicial implications for due process and implications on a society’s freedom of speech (Almagro et al., 2023; Tegrarian, 2025). As such, it is necessary to understand the mechanisms that give rise to this phenomenon, particularly the cognitive and emotional processes that transform individual moral judgments into collective punitive action (Aguiar et al., 2025).

While sociological approaches have documented cancel culture's prevalence, and philosophical analyses provide ethical frameworks, there has been little exploration of the psychological mechanisms underpinning cancel culture. Social media creates a new social environment that provides a foundation

for retributive punishment, where users have the capacity to make constant, rapid, emotive judgements regarding the behaviour and harmful actions of others (Feather, 1999; Saulnier & Sivasubramaniam, 2018). Thus, we may be able to garner an understanding of this new iteration of social ostracisation and punishment through the psychological framework of the retributive impulse.

Retributive Impulse

From a psychological perspective, cancel culture could be conceptualised as an expression of the retributive impulse: the strong urge to punish wrongdoers based on perceived deservingness (Carlsmith & Darley, 2008). These impulses are thought to enforce social norms, deter transgressions, and restore moral balance. Cancel culture follows a similar logic: individuals who violate moral or social norms are seen as deserving of reputational harm or exclusion. Those who enact these cancellations are also restoring the balance in their own group's sense of moral order (Okimoto & Wenzel, 2011). However, traditional retributive justice assumes clear wrongdoing, proportional punishment, and legitimate institutional authority (Okimoto et al., 2012). These conditions are systematically violated in cancel culture where facts are contested, consequences escalate unpredictably, and mob rule replaces institutional oversight. Although proponents of cancel culture claim that cancelling performs a function of social utility (Pearson, 2021), it is an empirical question whether the behaviour is in fact driven by retribution.

The justification for punishment can vary from being retributive in nature, to deterrence-based, or more restorative (Carlsmith, 2006; Wenzel & Okimoto, 2016). However, the justice literature suggests that punitive behaviours and sentiment are largely driven by anger and retribution rather than social utility (Wenzel & Okimoto, 2016). Carlsmith and Darley's (2008) review explored psychological aspects of punishment and concluded that people predominantly punish for retributive (or just desserts), rather than deterrent, reasons. Moral outrage has been identified as a key predictor of retributive responses (Carlsmith & Darley, 2008; Haidt, 2001; Wenzel & Okimoto, 2016). This is important as moral outrage is theorised to be the predominant form of content expressed in cancellations (Norris, 2023). Extending this existing literature to cancel culture suggests that cancelling behaviour would be driven by retribution as much as, if not more than, social utility.

Notably, existing psychological literature on punishment often employ hypothetical scenarios with clear transgression parameters, whereas real-world cancellations in social media contexts often involve ambiguous violations, evolving social norms, and group pressures (Feather, 1999; Socia et al., 2021). Therefore, it is not yet clear whether the retributive impulse manifests in digital arenas, driving cancelation. Our study aims to fill this gap in the literature by utilising an ambiguous transgression with social media group pressures built in. Social media platforms do not merely host social interactions, they fundamentally restructure them through algorithmic curation, network effects, and the collapse of temporal-spatial boundaries that historically contained punishment (Rathje et al., 2021). Therefore, unpacking whether the retributive impulse is expressed in cancel culture is not purely dependent on psychological punishment mechanisms. It is also influenced by the environment where these impulses

are expressed.

Social Media and Echo Chambers

Cancel culture-like phenomena have existed in various forms throughout history, however, its recent proliferation cannot be disentangled from social media. The creation of social media platforms and their algorithmic feeds have radically altered not only how information is accessed but also how opinions are formed (Cinelli et al., 2021). Social media platforms rely on algorithms to increase user engagement, funnelling users into echo chambers (Pearson, 2021). Echo chambers lead users to primarily interact with highly personalised content from individuals who have similar views to themselves, with little exposure to opposing viewpoints (Cinelli et al., 2021; Rhodes, 2022). A byproduct of this process is the creation of highly polarised ideological groups, where various prosocial behaviours, such as conformity and group serving bias, become maladaptive (Aguiar et al., 2025; Bouvier, 2020; Cinelli et al., 2021; Crockett, 2017). Digital environments also potentially amplify moral outrage by reducing empathy and increasing willingness to inflict severe consequences (Baccarella et al., 2018; Bouvier, 2020), due to online contexts stripping away social cues that typically moderate punishment responses. This amplification may also be due to the cohesive nature of discussion within each polarised group as retributive motives have been shown to drive this (McCrea et al., 2022). Moreover, echo chambers appear to operate as sophisticated consensus manufacturing systems that create and maintain illusions of universal agreement regarding both transgression severity and punishment appropriateness, potentially exploiting multiple cognitive biases simultaneously (Cinelli et al., 2021; Rhodes, 2022).

The false consensus effect, seeing one's behaviours or judgements as relatively common, becomes particularly pronounced as algorithmic curation and motivated reasoning synergistically create unanimity perceptions where none might exist (Luzsa & Mayr, 2021; Ross et al., 1977). Geschke et al. (2019) demonstrate that perceived social media consensus significantly exceeds actual opinion uniformity, strengthening the argument that users observe carefully curated streams of like-minded responses whilst remaining unaware of dissenting viewpoints filtered by both algorithms and selective attention. When apparent unanimous condemnation validates and amplifies moral outrage and anger towards a target, it also creates psychological pressure to match or exceed demanded consequence severity, akin to conformity (Asch, 1956; Rathje et al., 2021). Conformity or social influence can have a substantial impact on the perception of appropriate or proportionate punishment in online contexts. Conversely a small amount of dissent, even a single comment or two can, bring down the conformity pressures within in an echo chamber. Critically, much of the research in this area relies on observational or discourse studies that examine large swathes of social media data (Brady et al., 2021; Cinelli et al., 2021; McLoughlin et al., 2024). Brady et al. (2021)'s work examined over 12.7 million tweets of moral outrage expressions online and examined how moral expressions are influenced by norm learning. In a follow up behavioural study they found that moral outrage expression increased if participants were exposed to the echo chamber like conditions they created. However, their work was examining the spread of disinformation in online networks and may not extend to punishment behaviour. Despite limitations in this space and a relative dearth of literature, there remains a strong theoretical underpinning for analysing cancel culture through a retributive lens influenced by echo chambers. Taken

together, echo chambers likely validate retributive sentiments and amplify outrage, which, in turn, likely heightens the retributive impulse. This theoretical understanding is the conceptual foundation of this study, which aims to test these observational findings. However, it is well-established that individuals differ in terms of how they generally process information, suggesting that cancelation behaviours in online settings might not impact everyone the same way. Understanding cancel culture requires examining why these environmental drivers affect people differently.

Individual Differences

Although echo chambers likely exert powerful social influence over one's attitudes and behaviours, individuals may differ in the degree to which they are swayed by information they view online. As there have been mixed findings regarding individual differences in engagement in cancel culture based on political partisanship and other group memberships, this study instead focuses on cognitive processing models (Mueller, 2021). To our knowledge our study is the first to examine cognitive processes in this space. Dual-process theories posit that people differ in their propensity to engage with what is termed System 1 and System 2 reasoning (Evans, 2003, 2010; Tversky & Kahneman, 1974). System 1 is associated with fast, intuitive, and emotional thinking, whereas System 2 reflects a preference to engage with slow, deliberative, and reflective thinking. The individual differences people display in propensity towards cognitive processing by System 1 or System 2 may influence susceptibility to echo chamber effects. The dual-process framework has faced criticism, with critics arguing that the System 1 and System 2 dichotomy oversimplifies cognitive processing and may be better conceptualised as a continuum (Melnikoff & Bargh, 2018). However, it does provide a useful framework for analysing individual processes in this complicated space.

There is a strong body of evidence that outlines the role anger plays in both the triggering and the expression of the retributive impulse (Preece et al., 2019; Sivasubramaniam, 2017). Emotional reactivity, a component of emotional regulation, can be seen as brief states of emotional response that allows humans to discriminate between good and bad stimuli and give rise to certain responses to the stimuli (Becerra & Campitelli, 2013). Those high in negative emotional reactivity typically struggle to regulate anger so may experience stronger retributive activation coupled with reduced cognitive control, specifically impairing punishment response moderation (Preece et al., 2019). The intense arousal characteristic of high reactivity enhances System 1 reliance leading to rapid retribution-focused judgements with minimal proportionality consideration. These individuals may be particularly vulnerable to echo chamber effects because emotional flooding prevents the cognitive distance necessary for critical evaluation. This prediction, however, is theoretically derived and lacks direct empirical support at the time of writing.

Conversely, System 2 can be mapped onto Need for Cognition, reflecting stable motivational differences in effortful cognitive processing engagement, which serves as a potential protective factor against echo chamber influence online (Cacioppo & Petty, 1982). High Need for Cognition individuals demonstrate preferences for systematic evaluation, contextual consideration, and proportional consequence

matching (Lins De Holanda Coelho et al., 2020). These processing preferences should theoretically promote measured responses through deliberative assessment, active perspective-seeking, and resistance to echo chambers' influences that may be driving punishment escalation. However, Van Bavel and Pereira (2018) complicate this picture, showing that analytical thinking reduces belief in false information but does not eliminate motivated reasoning entirely, suggesting that even high Need for Cognition individuals succumb to echo chamber effects when content aligns with their values. The interaction between these individual differences and online environmental factors related to cancel culture remains underexplored.

Current Study

The aim of this study was to investigate whether cancelling behaviour is driven by the retributive impulse and the presence of echo chambers. Moreover, we tested Need for Cognition and Emotional Reactivity as potential moderators. Specifically, we investigate whether experimentally manipulating the presence of echo chambers via mock social media post can shape punishment attitudes towards an individual and whether this is explained by the retributive impulse. To the best of our knowledge, no research has applied the justice literature to cancel culture, our study aims to fill this gap. We put forward four hypotheses:

H1: Participants the echo chamber condition will display higher punitive sentiment than those in the no echo chamber condition.

H2: Participants in the echo chamber condition will display higher anger which will in turn lead to an increase in punitive sentiment.

H3: Emotional reactivity will moderate the indirect effect of anger on the relationship between echo chamber and punitive sentiment. Namely, there will be a significant indirect effect of anger for those with high emotional reactivity, but not for those with low emotional reactivity.

H4: Need for cognition will moderate the indirect effect of anger on the relationship between echo chamber and punitive sentiment. Namely, there will be a significant indirect effect of anger for those with low Need for Cognition, but not for those with high Need for Cognition.

Method

Participants

One hundred and fifty-six participants were recruited through the Research Experience Participation (REP) program at XXXX University of Technology, receiving 0.5 course credit in exchange for their time, and via the survey platform Prolific, receiving payment for their time ($5.20). Participants needed to be over 18 years old, able to comprehend English sufficiently to understand the information statement and located in Australia at the time of testing. After data cleaning there was 126 participants in our final

sample, ages ranged from 18–79 with an average age of 33 (*SD* = 14.25) (details regarding participant removal can be found in the results). Table 1 provides a breakdown of the participants included in the current study (see appendix C for relevant output).

Table 1
Sample Characteristics

Source	**REP**		**Prolific**		**Overall**	
Number of participants	59		67		126	
	n	%	*n*	%	*n*	%
Gender	16	27.1	34	50.8	50	39.7
Males	41	69.5	32	47.8	73	57.9
Females	1	1.7	1	1.4	2	1.6
Non-binary/third gender	1	1.7%	0	0	1	.8
Prefer not to say						
Ethnicity	32	54.2	37	55.2	69	54.8
Australian (Non-Indigenous)						
European	4	6.8	7	10.4	11	8.4
Asian	17	28.8	17	25.4	34	27
Other	6	9.8	6	11.2	12	10.5
	n	%	*n*	%	*n*	%
Student status	59	100	9	13.4	68	54
Student	0	0	58	86.6	58	46
Non-student						
Condition	34	57.6	39	58.2	73	57.9
Echo chamber	25	42.4	28	41.8	53	42.1
No echo chamber						
Note. n = number, *M* = Median, *SD* = Standard Deviation						

Design

This study employed a single-factor between-subjects (echo chamber vs. no echo chamber) experimental design. Participants were randomly allocated to either the echo chamber or no echo chamber condition and presented with a mock social media post that consisting of a call to cancel a university professor. Comments on the post were either consistent (echo chamber) or mixed (no echo

chamber) in supporting the cancelation. The dependent variable was punitive sentiment towards the target of the cancellation. Need for Cognition and negative Emotional Reactivity were also measured as potential moderators, and anger was measured as a potential mediator.

Measures and Materials

Other measures were used, and qualitative responses were recorded, however they are outside the scope of this paper (A full set of study materials can be seen on https://osf.io/b6hte/overview?view_only=1459bf6ef379458888898860754e26b7).

Experimental Vignettes

Participants read a fictional vignette presented as a social media post that called for the cancellation of a professor. The vignettes were designed using the assistance of Claude, a generative AI. Two versions of the vignette were created by manipulating the presence of an echo chamber. In both conditions, the original post in the thread displays a student named Jessica Thompson describing and reacting negatively to teaching about racial disparities in policing by a Professor Wilson. Following the original post, participants in the echo chamber condition saw six comments supporting cancellation of the target. In the other condition, participants saw three comments supporting cancellation and three dissenting comments dismissing or disagreeing with the original poster (see appendix A). Pilot tests were conducted with 39 participants, to ensure the manipulation operated as intended. (Pilot data was not included in the final sample, see OSF for data file https://osf.io/b6hte/overview?view_only=1459bf6ef379458888898860754e26b7).

Checks

An attention check was included prior to the vignette, participants were to read and skip the question and after the manipulation checks another attention check was added where a particular answer was instructed to be selected. Failure on either check resulted in the participant's data being excluded from analyses.

Six emotion checks (adapted from (Goldberg et al., 1999; Gross & Levenson, 1995; Izard et al., 1974) were included immediately after the vignette to gauge whether participants were responding with appropriate emotion to the social media post (see Appendix E). On a 7-point Likert scale participants self-reported their emotional responses to the vignette: "How much anger/contempt/disgust/fear/happiness/sadness did you feel?" (1 = not even the slightest bit to 7 = most intensely), with participants expected to score above the midpoint on anger and below the midpoint on happiness if they were responding to the vignette as we expected. Participants' responses on the anger item constituted the anger mediator.

A categorical and a continuous manipulation check were included following the emotion checks. The categorical check asked participants about the type of comments they saw following the post “In the scenario, the comments on Jessica's social media post were?” with participants in the echo chamber condition to select “primarily critical comments condemning professors Wilson’s teaching approach”. Whereas participants in the no echo chamber were to select “Mixed comments with both critical and supportive viewpoints”, and participants who failed the categorical check were excluded from the analyses. The continuous manipulation check asked participants to rate the consistency of the comments they read in response to the post on a Likert scale (1 = Very consistent to 5 = Highly varied). Participants in the echo chamber were expected to score lower than those in the no echo chamber.

Perth Emotional Reactivity Scale - Short-Form

Emotional reactivity was measured using nine items that make up the general negative reactivity subset of items from the Perth Emotional Reactivity Scale (Preece et al. (2019). This self-report scale measures the typical ease of activation, intensity, and duration of emotional responses on a 5-point Likert scale (1 = very unlike me to 5 = very like me). Statements include, “Once in a negative mood, it's hard to snap out of it”. Higher scores reflect higher propensity to negative emotional reactivity. The general negative reactivity factors has excellent reliability (α = .91).

Need for Cognition Scale-short form

Need for Cognition was assessed via six-item’s from Lins De Holanda Coelho et al. (2020) shortened version of the Need for Cognition scale (NCS-6). Designed to measure how much participants enjoy effortful thinking on a 5-point Likert scale (1 = extremely uncharacteristic of me to 5 = extremely characteristic of me). Statements include, “I really enjoy a task that involves coming up with new solutions to problems”. Higher scores indicate higher Need for Cognition. The NCS-6 has well establish psychometric properties (α = .90; Lins De Holanda Coelho et al. (2020).

Punitive Sentiment

A single item measured punitive sentiment towards the target of cancellation: "Professor Wilson deserves to be punished for his teaching approach regarding racial disparities in policing", 1 = strongly disagree to 7 = strongly agree. Higher scores indicate stronger punitive sentiment.

Procedure

Ethics approval

was granted by XXXX University Human Research Ethics Committee (SUHREC- 20258845-22053; see Appendix B). The study was conducted online via Qualtrics. After providing consent, participants were asked for basic demographic information. Participants then completed two measures: the Perth Emotional Reactivity Scale and the Need for Cognition Scale. Participants were then asked an attention check question. Participants were randomly allocated to read one of two experimental vignettes, consisting of a fictional social media post and comments on that post. After reading the social media

post and comments, the participants were invited to write a comment that they might add to the social media post if they had actually seen it on their feed. Participants then completed the emotion checks, followed by the two manipulation checks, another attention check, and then the single item measuring punitive sentiment. Finally, participants were debriefed. Participation took approximately 12 minutes.

Results

Data Screening and Assumption Tests

A total of 30 participants were removed prior to data analyses, leaving 126 responses. Participant data were removed if they had more than 30% of responses missing (Tabachnick & Fidell, 2018) or failed either an attention check (n = 2) or the categorical manipulation check (n = 26). Following data screening, no missing values remained, therefore data imputation was not needed. Before analyses, assumptions of normality, multicollinearity, linearity, homoscedasticity, and independence of residuals were checked and met for a moderated mediation (See Appendix C for a detailed report of assumption tests.) There were no outliers in the data set. It should be noted that PROCESS bootstrapping corrects for normality, homoscedasticity, and linearity. Assessing power for a moderated mediation is not directly possible, however there is a method using G*power to arrive at an approximate necessary sample. Using the method suggested by Regorz (2024) an a priori power analysis using G*power (version 3.1) calculated the sample size needed to detect an anticipated effect size of f^2=.085, with 3 total predictors (Appendix F). It was determined that a sample of 124 could produce a medium effect size at sufficient power (.80). Data collection was stopped when reviewed participants' data appeared to be over the required amount.

A t-test was conducted on the continuous manipulation check confirmed that there was a significant difference $t(124) = -17.75$, $p < .001$) in perceived heterogeneity of comments between those in the echo chamber (M = 1.66, SD = .69), and no echo chamber conditions (M = 4.02, SD = .80).

Descriptive Statistics

Table 2 below presents the key descriptive statistics for emotion checks, as well as differences in self-reported emotions across conditions. Mean scores for anger, contempt and disgust were not above the midpoint of the scale, suggesting that our stimuli evoked emotional responses, albeit not strongly. The Need for Cognition scale utilises a 5-point Likert scale, mean scores were approximately in the centre, consistent with the literature with this measure, Cronbach's alpha indicated very high internal consistency (α = .84). The Perth emotional reactivity short scale utilises a 5-point Likert scale, mean scores were approximately in the centre as well, and again Cronbach's alpha indicated very high internal consistency (α = .93). Punitive sentiment was measured using a single item on a 7-point Likert scale.

Table 2

Means and Standard Deviations of Emotion Checks and Main Variables Between Groups

	Overall		**Echo chamber**		**No Echo chamber**				
	M	***SD***	***M***	***SD***	***M***	***SD***	***t*(124)**	***p***	**Cohen's *d***
Anger	3.09	1.44	3.26	1.44	2.85	1.41	1.596	.113	.29
Contempt	3.14	1.50	3.38	1.53	2.81	1.39	2.151	.033*	.39
Disgust	3.40	1.72	3.66	1.69	3.06	1.70	1.962	.052	.35
Fear	1.98	1.30	2.08	1.43	1.85	1.10	.992	.323	.18
Happiness	1.45	.95	1.44	.82	1.47	1.12	− .193	.847	− .04
Sadness	3.13	1.70	3.18	1.67	3.06	1.75	.395	.693	.07
Punitive Sentiment	4.1	1.77	4.26	1.16	3.72	.89	2.847	.003*	.51
Need for cognition	3.39	.79	3.33	.76	3.48	.83	-1.103	.136	− .79
Emotional reactivity	2.94	.99	2.84	.97	3.06	1.01	-1.239	.109	− .22

Note. Echo Chamber (*n* = 59), No echo chamber (*n* = 67), *M* = Mean, *SD* = Standard Deviation. Mean values are displayed for the overall emotion scores as well as condition specific means. The results of t tests (assuming equal variance) for comparisons between groups are also displayed. * *p* = .05.

H1 & H2: Echo Chamber, Anger, and Punitive Sentiment

Hypotheses 1 and 2 were tested via a simple mediation analysis with Model 4 of the Hayes PROCESS Macro (Hayes, 2022). Echo chamber condition was entered as the predictor variable (*X*), anger was entered as the mediator (*M*) and punitive sentiment was entered as the outcome variable (*Y*). We used bootstrapping with 5,000 resamples to place confidence intervals around estimates of the indirect effects. (See Appendix D)

The simple mediation analysis showed that the overall model of Echo Chamber (predictor), punitive sentiment (outcome), and Anger (mediator) was not significant. $F(2,124) = 2.55$, $p = .113$, $R^2 = - .02$. As seen in Fig. 1 below, there was a significant positive total effect of echo chamber on punitive sentiment, *c* path: $t(123) = 5.34$, $p < 001$. When Anger was added to the model, the direct effect of echo chamber on punitive sentiment was still significant, *c'* path: $t(123) = 3.51$, $p < .001$. Anger independently also had a significant positive effect on punitive sentiment *b* path: $t(123) = 6.95$, $p < 001$. However, there was no significant effect of echo chamber on anger, *a* path: $t(124) = 1.60$, $p = .11$. There was also not a significant indirect effect of echo chamber on punitive sentiment through anger (*ab* path).

Figure 1

Statistical Path Unstandardised Coefficients for Simple Mediation

H3: Emotional reactivity

Next, we performed two separate moderated-mediation analyses using Hayes Process Macro (Model 7; Hayes, 2022). Specifically, we extended upon the simple mediation outlined above by entering Emotional Reactivity and Need for Cognition, respectively, to test whether each moderated the indirect effect of anger. Figures 2 and 3 present the statistical path diagrams outlining the simple effects of the moderated mediation analyses. (See Appendix D)

First, we performed the analysis with emotional reactivity as a moderator of the indirect effect. We found a significant positive direct effect of Echo chamber on punitive sentiment c' path $t(123) = 3.51$, $p < .001$, such that those in the echo chamber condition displayed more punitive sentiment than those in the no echo chamber condition. Similarly, echo chamber significantly positively predicted anger a^1 path: $t(122) = 2.01$, $p = .047$, and Emotional reactivity was significantly positively related to Anger a^2 path: $t(122) = 2.80$, $p = .006$. Further, anger was significantly and positively related to punitive sentiment, *b* path $t(123) = 6.95$, $p < .001$.

Figure 2

Statistical Path Diagram of the Moderated Mediation Analysis for Emotional Reactivity

Note

N = 126. All path coefficients represent unstandardised beta coefficients. The broken line depicts non-significant relationships. *SE* = standard error. * $p < .05$, ***$p < .001$.

However, there was little evidence that emotional reactivity moderated the indirect effect of anger on the relationship between echo chamber and punitive sentiment. The overall moderated mediation model was not significant, as indicated by the index of the moderated mediation through which the 95% CI included zero, (index = .16 95% CI [-.20, .51]).

H4: Need for Cognition

Second, we investigated Need for Cognition as a moderator of the indirect effect. Figure 3 presents the statistical path diagrams outlining the simple effects of the moderated mediation analyses. We found a significant positive direct effect of Echo chamber on punitive sentiment c' path $t(123) = 3.51$, $p < .001$, whereby those in the echo chamber condition displayed more punitive sentiment than those in no echo chamber condition. However, in this analysis, the echo chamber manipulation did not significantly predict anger a^1 path: $t(122) = 1.51$, $p = .134$, and Need for Cognition was not significantly related to

Anger a^2 path: $t(122) = -1.28$, $p = .204$. Further, anger was significantly and positively related to punitive sentiment, *b* path $t(123) = 6.95$, $p < .001$.

Figure 3

Statistical path Diagram of the Moderated Mediation Analysis for Need for Cognition

Note

N = 126. All path coefficients represent unstandardised beta coefficients. The broken line depicts non-significant relationships. *SE* = standard error. ***$p < .001$.

There was no evidence that Need for Cognition moderated the indirect effect of anger on the relationship between echo chamber and punitive sentiment. The overall moderated mediation model was not significant, as indicated by the index of the moderated mediation through which the 95% CI included zero, (index = .265, 95% CI [-.15, .72]).

Discussion

The current study explored whether engagement in cancel culture was influenced by the presence of an echo chamber via anger, and whether this was moderated by Need for Cognition or Emotional Reactivity. The findings provide support for some of the hypotheses and offer an insight into how social media may influence the impulse to punish in cancel culture contexts.

Echo chambers and Anger

As expected for Hypothesis 1, participants in the echo chamber condition displayed significantly higher punitive sentiment than those in the no echo chamber condition. This finding aligns with the theoretical frameworks of false consensus effects; wherein exposure to unanimous condemnation creates illusions regarding punishment appropriateness. Our experimental manipulation extends Brady et al. (2021) correlational findings from analysing over 12.7 million social media posts, which revealed that moral outrage expressions increase in ideologically homogeneous networks i.e. echo chambers, to punishment related behaviour. By experimentally isolating the echo chamber effect, we demonstrate that perceived consensus itself, independent of other social media features like viral sharing or algorithmic amplification can drive punitive attitudes. Notably, this effect emerged within a single experimental session using static vignettes, in contrast to the prolonged exposure typical of real-world cancellation events that can unfold over days or weeks. This suggests that the false consensus effect may be particularly potent in digital environments, where even brief encounters with apparent unanimity can escalate punitive responses.

Contrary to Hypothesis 2, participants in the echo chamber condition did not display higher anger leading to an increase in punitive sentiment, although anger was significantly and positively related to punitive sentiment. This is an unexpected finding, as this is a well-established link in justice literature, which challenges our assumptions about the emotional mechanisms driving cancel culture. The retributive justice literature suggests that moral outrage increases punishment desires to restore perceived justice (Tetlock et al., 2007), yet our results indicate that punitive escalation can occur even without corresponding emotional intensification. This is also an important contribution to the literature on two fronts, firstly this may confirm Levy (2021)'s supposition that the punishment seen in cancel culture through social media is transformed from a tool, serving psychological satisfaction and community restoration, into a performative moral virtue display, where consequence severity signals moral and group standing. Secondly, there have been recent studies examining the decoupling of expressions of moral outrage from its visceral correlates due to the design of social media (Brady et al., 2020; Crockett, 2017). The disconnect between emotional arousal and punitive behaviour suggests cancel culture may operate through more calculated conformity mechanisms than previously theorised. This interpretation also aligns with Carlsmith and Darley's (2008) distinction between hot retributive impulses and cold punishment calculations, suggesting that echo chambers may facilitate the latter rather than the former. These findings may be a strength of our methodologically flawed design and warrant further investigation. However, these findings should be interpreted with caution due to the low level of overall emotion evoked from our stimuli. Future research should also explore this further with more emotive stimuli as it may find results more aligned to retributive justice literature.

Cognitive Processing Individual Differences

Neither Hypothesis 3 nor Hypothesis 4 was supported by the data. Hypothesis 3 posited that emotional reactivity would moderate the indirect effect of anger on the relationship between echo chamber exposure and punitive sentiment, with stronger effects predicted for individuals high in emotional reactivity. Hypothesis 4 proposed that Need for Cognition would moderate this same indirect pathway, with individuals low in Need for Cognition expected to demonstrate stronger echo chamber effects. Both moderation models failed to achieve statistical significance.

The non-significant findings for emotional reactivity are inconsistent with predictions derived from dual-processing frameworks (Evans, 2010) regarding susceptibility to emotional manipulation in digital environments. The hypothesized amplification effect for individuals high in emotional reactivity was not observed. These results indicate that the relationship between echo chamber exposure and punitive sentiment, as mediated by anger, may not be systematically influenced by individual differences in emotional processing tendencies as operationalized by the Perth Emotional Reactivity Scale (Preece et al., 2019).

The absence of moderation by Need for Cognition warrants particular attention. Theoretical frameworks suggested that individuals high in Need for Cognition would demonstrate resistance to echo chamber influences through systematic information evaluation and critical analysis (Evans, 2010). However, no protective effect was observed. These findings suggest that conformity pressures within echo chambers

may supersede individual differences in cognitive processing preferences. Individuals characterized by high levels of effortful cognitive processing and resistance to peripheral persuasion attempts demonstrated comparable susceptibility to echo chamber influences on punitive sentiment.

These findings extend Asch's (1956) seminal conformity research to contemporary digital contexts, indicating that exposure to unanimous group judgments in online environments may exert influence independent of individual cognitive or emotional processing characteristics. The results are consistent with McLoughlin et al.'s (2024) conceptualization of "mindless" information sharing, wherein content is disseminated without comprehensive cognitive engagement. This phenomenon may account for the absence of the predicted buffering effect of Need for Cognition.

The failure to detect moderation effects for either personality variable has significant implications for theoretical models of digital mob dynamics. These findings suggest that social influence processes in online environments may operate through universal mechanisms that effect individuals irrespective of their emotional reactivity or cognitive processing preferences. Such results challenge the viability of intervention strategies based on individual differences and indicate that structural characteristics of digital environments may represent more appropriate targets for interventions aimed at mitigating problematic aspects of cancel culture phenomena. However, as with the mediation results, further research is required with more emotive stimuli as this may alter results substantially.

Limitations

Several methodological limitations warrant consideration when interpreting the current findings. There was a high failure rate of our categorical manipulation check with approximately 27% (20 of 75) of participants in the no echo chamber condition failing to correctly identify the comment section's mixed nature. This may suggest that participants engaged superficially with the materials (i.e., they didn’t read all the comments). The limitation could also be explained by the fixed ordering of comments across all conditions wherein participants saw the first two supportive to cancellation comments, and then either more supportive or dissenting comments. This possibly introduced primacy and recency effects which may have systematically influenced perception of consensus regardless of condition. Future research should look to alter the ordering of comments to potentially eliminate order effects.

Our vignette methodology failed to evoke as strong an emotional response as was desired. This failure is particularly problematic given our theoretical framework positioning emotional arousal as central to cancel culture dynamics (Tetlock et al., 2007). The emotional flatness of responses, below the midpoint in all categories, may explain why anger failed to mediate the echo chamber-punishment relationship and why emotional reactivity showed unexpected conditional patterns. This suggests our vignette may not have achieved sufficient moral contentiousness or that text-based stimuli inherently lack the visceral impact of real-world cancellations. This failure may also be explained by contextual effects as the comparison between real life social media use, where users are exposed to extreme violence and/or violations of moral norms e.g. Charlie Kirk shooting and resulting cancellations.

Future Directions

The unexpected finding that anger does not mediate echo chamber effects on punitive sentiment might suggest that some of the processes underlying traditional justice behaviours might not extend to cancel culture contexts. Future research should implement qualitative interview studies to identify potential mediating variables, before further quantitative research can investigate whether there are any meaningful relationships between echo chambers and the retributive impulse. Methodological innovations are also essential for capturing cancel culture's emotional and social complexity. Future studies should employ more immersive stimuli that better approximate the multimodal nature of online shaming. One particularly promising approach would be utilising AI-populated social media environments. Platforms such as Aspect, where all users except the participant are AI agents, could provide an immersive, controlled setting while potentially eliciting more genuine, unguarded reactions than traditional vignettes. Such platforms would allow researchers to systematically manipulate echo chamber dynamics, observe real-time escalation patterns, and capture the visceral emotional responses that static experimental vignettes may miss. These AI social media simulations could incorporate dynamic designs where participants observe cancellations unfolding in real-time, capturing the escalatory processes our static vignettes missed while maintaining experimental control over variables like comment consistency, timing of responses, and intensity of mob behaviour. This modality would also allow research to incorporate ingroup vs. outgroup manipulations which would dramatically increase ecological validity, as real cancellations typically involve strong tribal affiliations that amplify both emotional responses and conformity pressures.

Conclusion

Our study provides limited empirical evidence for understanding cancel culture as an expression of the retributive impulse, whilst highlighting the complexity of understanding this phenomenon. The robust direct effect of echo chambers on punitive sentiment confirms that consensus environments drive cancel culture behaviours, validating echo chambers as a primary mechanism. The direct effect of the retributive impulse to punitive sentiment also indicates the retributive impulse plays a factor in the behavioural expressions in cancel culture. However, the pathways underlying this effect proved more complex than theorized. Anger did not mediate the echo chamber-punishment relationship in our primary analysis. Suggesting that cancel culture may not be predominantly driven by its emotional component as initially conceptualised. Also, of note neither Emotional Reactivity nor Need for Cognition buffered against echo chamber effects indicating that the cognitive component may be insufficient to override group level dynamics. This may be indicative of conformity effects, this requires follow up studies. Our study also did not examine the social utility component of cancel culture, the extent to which individuals engage in this phenomenon to signal group membership, or reinforce moral boundaries, which remains under explored. Future research must employ more immersive methodologies with varying stimulus strength to better capture the escalatory dynamics that transform individual judgments into collective digital punishment, while also disentangling the relative

contributions of social, emotional, cognitive and social utility components of this multifaceted phenomenon.

Declarations

Author Contribution

Conceptualisation: J.M,T.G. & D.S.Methodology: J.M,T.G. & D.S.Validation: J.M,T.G. & D.S.Formal analysis: J.M.Investigation: J.M.Data Curation J.M.Writing - Original Draft: J.M.Writing - Review & Editing: J.M,T.G. & D.S.Visualisation: J.M. & T.G.Supervision: T.G. & D.S.Funding acquisition: J.M & T.G.

Data Availability

Data can be found on the anonymous OSF page https://osf.io/b6hte/overview?view_only=1459bf6ef379458888898860754e26b7

References

1. Aguiar, T. R., Lopes, D., & Brooks, T. R. (2025). Qualitative Insights Into Cancel Culture Prevention, Its Potential Individual Impacts, and How to Explore them. *Human Behavior and Emerging Technologies*, *2025*(1). https://doi.org/10.1155/hbe2/8479135
2. Almagro, M., Hannikainen, R., I., & Villanueva, N. (2023). Who Has a Free Speech Problem? Motivated Censorship Across the Ideological Divide. In (pp. 215–237). Springer International Publishing. https://doi.org/10.1007/978-3-031-28908-8_11
3. Asch, S. E. (1956). Studies of independence and Conformity: I. A Minority of One Against a Unanimous Majority. *Psychological Monographs: General and Applied*, *70*(9), 1–70. https://doi.org/10.1037/h0093718
4. Baccarella, C. V., Wagner, T. F., Kietzmann, J. H., & McCarthy, I. P. (2018). Social media? It's serious! Understanding the dark side of social media. *European Management Journal*, *36*(4), 431–438. https://doi.org/10.1016/j.emj.2018.07.002
5. Becerra, R., & Campitelli, G. (2013). Emotional Reactivity: Critical Analysis and Proposal of a New Scale. *International Journal of Applied Psychology*, *2013*, 161–168. https://doi.org/10.5923/j.ijap.20130306.03
6. Bouvier, G. (2020). Racist Call-Outs and Cancel Culture on Twitter: The Limitations of the Platform's Ability to Define Issues of Social Justice. *Discourse Context & Media*, *38*, 100431. https://doi.org/10.1016/j.dcm.2020.100431
7. Brady, W. J., Crockett, M. J., & Van Bavel, J. J. (2020). The MAD Model of Moral Contagion: The Role of Motivation, Attention, and Design in the Spread of Moralized Content Online. *Perspectives on Psychological Science*, *15*(4), 978–1010. https://doi.org/10.1177/1745691620917336

8. Brady, W. J., McLoughlin, K., Doan, T. N., & Crockett, M. J. (2021). How Social Learning Amplifies Moral Outrage Expression in Online Social Networks. *Science Advances*, *7*(33), eabe5641. https://doi.org/10.1126/sciadv.abe5641
9. Cacioppo, J. T., & Petty, R. E. (1982). The Need for Cognition. *Journal of Personality and Social Psychology*, *42*(1), 116–131. https://doi.org/10.1037/0022-3514.42.1.116
10. Carlsmith, K. M. (2006). The Roles of Retribution and Utility in Determining Punishment. *Journal of experimental social psychology*, *42*(4), 437–451. https://doi.org/10.1016/j.jesp.2005.06.007
11. Carlsmith, K. M., & Darley, J. M. (2008). Psychological Aspects of Retributive Justice. In *Advances in Experimental Social Psychology* (Vol. 40, pp. 193–236). Academic Press. https://doi.org/https://doi.org/10.1016/S0065-2601(07)00004-4
12. Cinelli, M., De Francisci Morales, G., Galeazzi, A., Quattrociocchi, W., & Starnini, M. (2021). The Echo Chamber Effect on Social Media. *Proceedings of the National Academy of Sciences*, *118*(9), e2023301118. https://doi.org/10.1073/pnas.2023301118
13. Clark, M. (2020). DRAG THEM: A Brief Etymology of So-Called Cancel Culture. *Communication and the Public*, *5*(3–4), 88–92. https://doi.org/10.1177/2057047320961562
14. Crockett, M. J. (2017). Moral outrage in the digital age. *Nature Human Behaviour*, *1*(11), 769–771. https://doi.org/10.1038/s41562-017-0213-3
15. Evans, J. S. B. T. (2003). In Two Minds: Dual-Process Accounts of Reasoning. *Trends in Cognitive Sciences*, *7*(10), 454–459. https://doi.org/10.1016/j.tics.2003.08.012
16. Evans, J. S. B. T. (2010). Intuition and Reasoning: A Dual-Process Perspective. *Psychological Inquiry*, *21*(4), 313–326. https://doi.org/10.1080/1047840x.2010.521057
17. Feather, N. T. (1999). Judgments of Deservingness: Studies in the Psychology of Justice and Achievement. *Personality and social psychology review*, *3*(2), 86–107. https://doi.org/10.1207/s15327957pspr0302_1
18. Geschke, D., Lorenz, J., & Holtz, P. (2019). The Triple-Filter Bubble: Using Agent-Based Modelling to Test a Meta-Theoretical Framework for the Emergence of Filter Bubbles and Echo Chambers. *British Journal of Social Psychology*, *58*(1), 129–149. https://doi.org/10.1111/bjso.12286
19. Goldberg, J. H., Lerner, J. S., & Tetlock, P. E. (1999). Rage and Reason: The Psychology of the Intuitive Prosecutor. *European Journal of Social Psychology*, *29*(5–6), 781–795. https://doi.org/10.1002/(sici)1099-0992(199908/09)29:5/6%3C781::aid-ejsp960%3E3.0.co;2-3
20. Gross, J. J., & Levenson, R. W. (1995). Emotion Elicitation Using Films. *Cognition & Emotion*, *9*(1), 87–108. https://doi.org/10.1080/02699939508408966
21. Hayes, A. F. (2022). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*. Guilford. http://ebookcentral.proquest.com/lib/swin/detail.action?docID=6809031
22. Izard, C. E., Dougherty, F. E., Bloxom, V. M., & Kotsch, W. E. (1974). The Differential Emotions Scale: A method of Measuring the Subjective Experience of Discrete Affect. [Unpublished manuscript.].

23. Levy, N. (2021). Virtue Signalling is Virtuous. *Synthese*, *198*(10), 9545–9562. https://doi.org/10.1007/s11229-020-02653-9
24. Coelho, L. D. H., Hanel, G. H. P., P., & Wolf, J., L (2020). The Very Efficient Assessment of Need for Cognition: Developing a Six-Item Version. *Assessment*, *27*(8), 1870–1885. https://doi.org/10.1177/1073191118793208
25. Luzsa, R., & Mayr, S. (2021). False Consensus in the Echo Chamber: Exposure to Favorably Biased Social Media News Feeds Leads to Increased Perception of Public Support for Own Opinions. *Cyberpsychology*: *Journal of Psychosocial Research on Cyberspace*, *15*(1). https://doi.org/10.5817/cp2021-1-3
26. Marinovic, I., Cianciaruso, D., & Guttman, I. (2022). Cancel Culture and Social Learning. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4011359
27. McCrea, S. M., Erion, C. J., & Thürmer, J. L. (2022). Why Punish Critical Outgroup Commenters? Social Identity, General Norms, and Retribution. *British Journal of Social Psychology*, *61*(3), 711–728. https://doi.org/10.1111/bjso.12508
28. McLoughlin, K. L., Brady, W. J., Goolsbee, A., Kaiser, B., Klonick, K., & Crockett, M. J. (2024). Misinformation Exploits Outrage to Spread Online. *Science*, *386*(6725), 991–996. https://doi.org/10.1126/science.adl2829
29. Melnikoff, D. E., & Bargh, J. A. (2018). The Mythical Number Two. *Trends in Cognitive Sciences*, *22*(4), 280–293. https://doi.org/10.1016/j.tics.2018.02.001
30. Mueller, T. S. (2021). Blame, then Shame? Psychological Predictors in Cancel Culture Behavior. *The Social Science Journal*, 1–14. https://doi.org/10.1080/03623319.2021.1949552
31. Ng, E. (2020). No Grand Pronouncements Here… Reflections on Cancel Culture and Digital Media Participation. *Television & New Media*, *21*(6), 621–627. https://doi.org/10.1177/1527476420918828
32. Norris, P. (2023). Cancel Culture: Myth or Reality? *Political Studies*, *71*(1), 145–174. https://doi.org/10.1177/00323217211037023
33. Okimoto, T. G., & Wenzel, M. (2011). Third-Party Punishment and Symbolic Intragroup Status. *Journal of Experimental Social Psychology*, *47*(4), 709–718. https://doi.org/10.1016/j.jesp.2011.02.001
34. Okimoto, T. G., Wenzel, M., & Feather, N. T. (2012). Retribution and Restoration as General Orientations towards Justice. *European Journal of Personality*, *26*(3), 255–275. https://doi.org/10.1002/per.831
35. Pearson, D. H. (2021). *Accountability, Exile and Social Media: An Analysis of Contemporary Online Public Shaming Practices and*. Cancel Culture.
36. Preece, D., Becerra, R., & Campitelli, G. (2019). Assessing Emotional Reactivity: Psychometric Properties of the Perth Emotional Reactivity Scale and the Development of a Short Form. *Journal of Personality Assessment*, *101*(6), 589–597. https://doi.org/10.1080/00223891.2018.1465430
37. Rathje, S., Van Bavel, J. J., & Van Der Linden, S. (2021). Out-Group Animosity Drives Engagement on Social Media. *Proceedings of the National Academy of Sciences*, *118*(26), e2024292118. https://doi.org/10.1073/pnas.2024292118

38. Regorz, A. (2024). Sample Size for a Moderated Mediation.
39. Using G*Power https://www.regorz-statistik.de/en/power_moderated_mediation.html
40. Rhodes, S. C. (2022). Filter Bubbles, Echo Chambers, and Fake News: How Social Media Conditions Individuals to Be Less Critical of Political Misinformation. *Political Communication*, *39*(1), 1–22. https://doi.org/10.1080/10584609.2021.1910887
41. Ross, L., Greene, D., & House, P. (1977). The False Consensus Effect: An Egocentric Bias in Social Perception and Attribution Processes. *Journal of Experimental Social Psychology*, *13*(3), 279–301. https://doi.org/10.1016/0022-1031(77)90049-x
42. Saulnier, A., & Sivasubramaniam, D. (2018). Restorative Justice: Reflections and the Retributive Impulse. In (pp. 177–210). Springer International Publishing. https://doi.org/10.1007/978-3-319-75859-6_6
43. Sivasubramaniam, D. (2017). The justice motive: Psychological research on perceptions of justice incriminal law. *Australia: Essays in contemporary law reform*, *New directions for law in* (pp. 181–190). https://doi.org/10.22459/ndla.09.2017
44. Socia, K. M., Rydberg, J., & Dum, C. P. (2021). Punitive Attitudes Toward Individuals Convicted of Sex Offenses: A Vignette Study. *Justice Quarterly*, *38*(6), 1262–1289. https://doi.org/10.1080/07418825.2019.1683218
45. Tabachnick, B., & Fidell, L. (2018). *Using Multivariate Statistics*. Pearson Education. http://ebookcentral.proquest.com/lib/swin/detail.action?docID=5894255
46. Tegrarian, R. J. (2025). *A Psychological Theory for Accountability/Cancel Culture and Personality Typology: A Theory of Personality Characteristics and Moral Values Associated with Accountability/Cancel Culture* (Publication Number 30995909) [Ph.D., Fielding Graduate University]. ProQuest Dissertations & Theses Global: The Sciences and Engineering Collection. United States -- California. https://www.proquest.com/dissertations-theses/psychological-theory-accountability-cancel/docview/2954736408/se-2?accountid=14205
47. Tetlock, P. E., Visser, P. S., Singh, R., Polifroni, M., Scott, A., Elson, S. B., Mazzocco, P., & Rescober, P. (2007). People as intuitive prosecutors: The impact of social-control goals on attributions of responsibility. *Journal of Experimental Social Psychology*, *43*(2), 195–209. https://doi.org/10.1016/j.jesp.2006.02.009
48. Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science*, *185*(4157), 1124–1131. http://www.jstor.org/stable/1738360
49. Van Bavel, J. J., & Pereira, A. (2018). The Partisan Brain: An Identity-Based Model of Political Belief. *Trends in Cognitive Sciences*, *22*(3), 213–224. https://doi.org/10.1016/j.tics.2018.01.004
50. Wenzel, M., & Okimoto, T. G. (2016). Retributive Justice. In (pp. 237–256). Springer New York. https://doi.org/10.1007/978-1-4939-3216-0_13

Figures

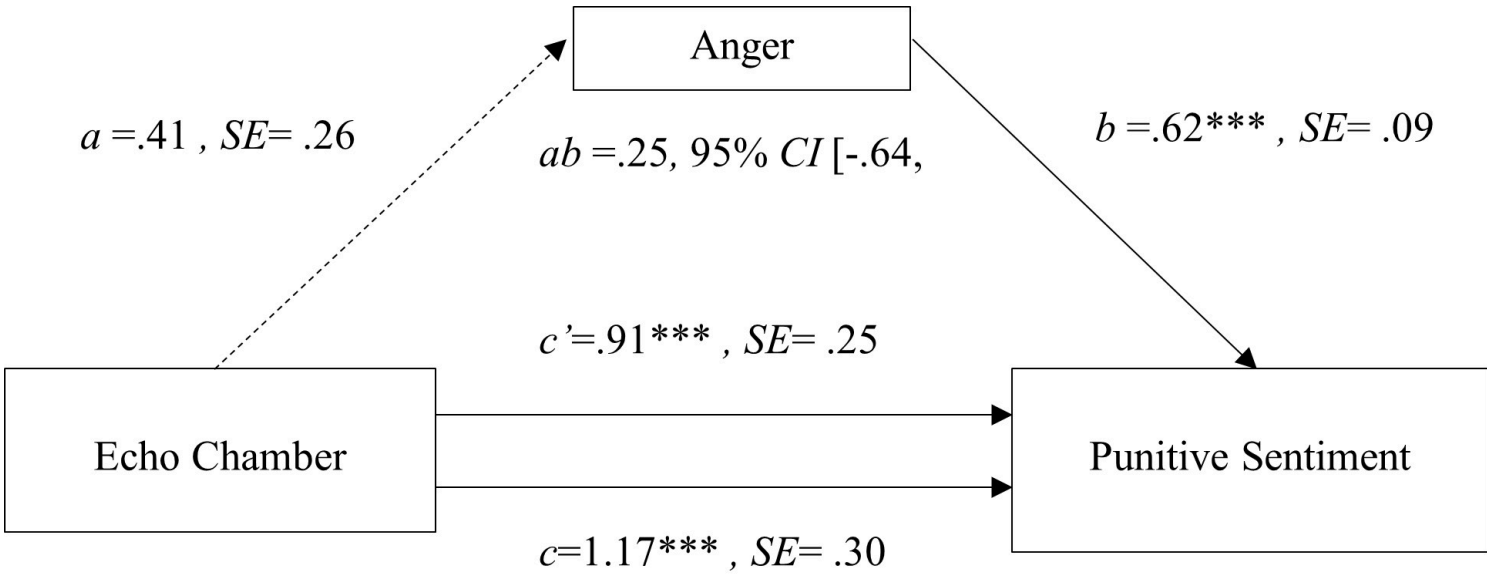


Figure 1

Statistical Path Unstandardised Coefficients for Simple Mediation

Note. N = 126. All path coefficients represent unstandardised beta coefficients. The broken line depicts non-significant relationships. *SE* = Standard Error. *CI* = Confidence Interval. c'= Direct effect. ***p <.001.

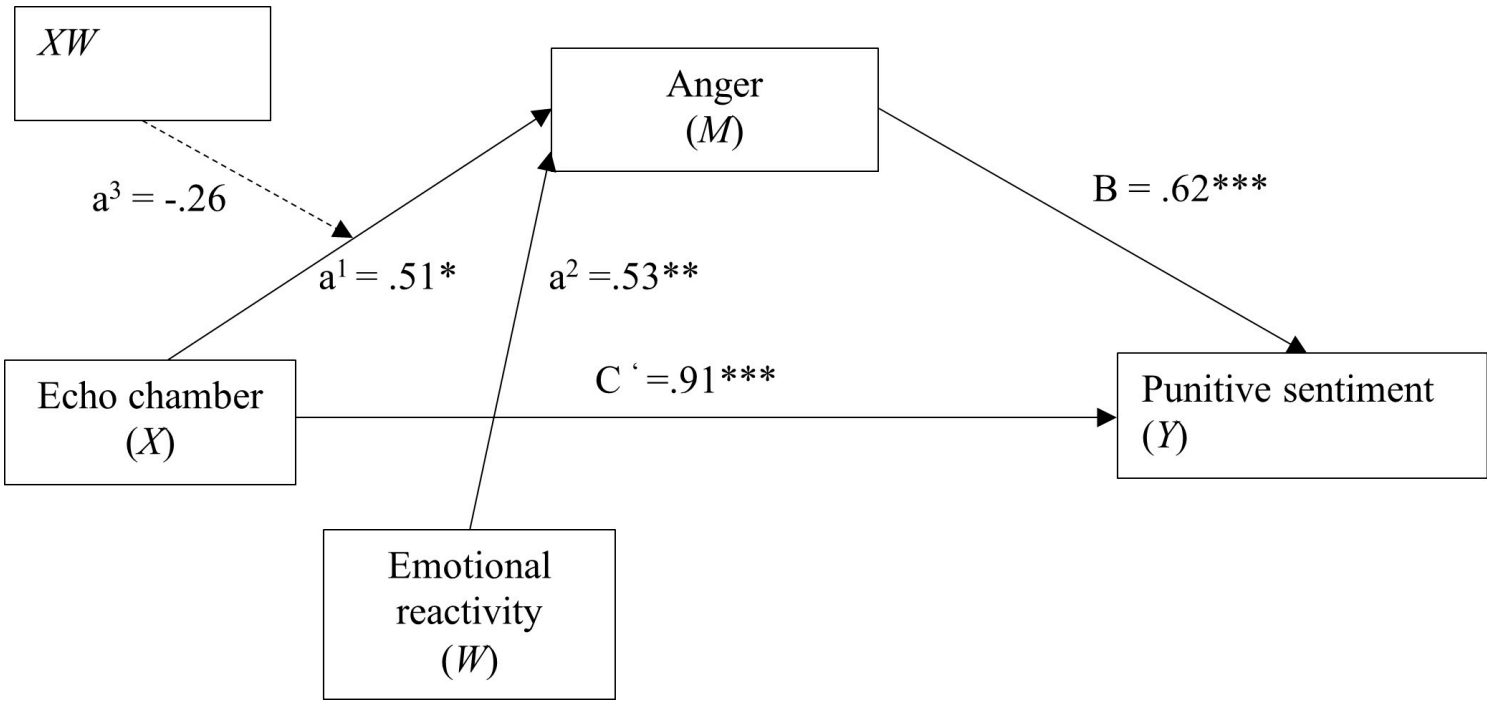


Figure 2

Statistical Path Diagram of the Moderated Mediation Analysis for Emotional Reactivity

Note. *N* = 126. All path coefficients represent unstandardised beta coefficients. The broken line depicts non-significant relationships. *SE* = standard error. * *p* <.05, ****p* <.001.

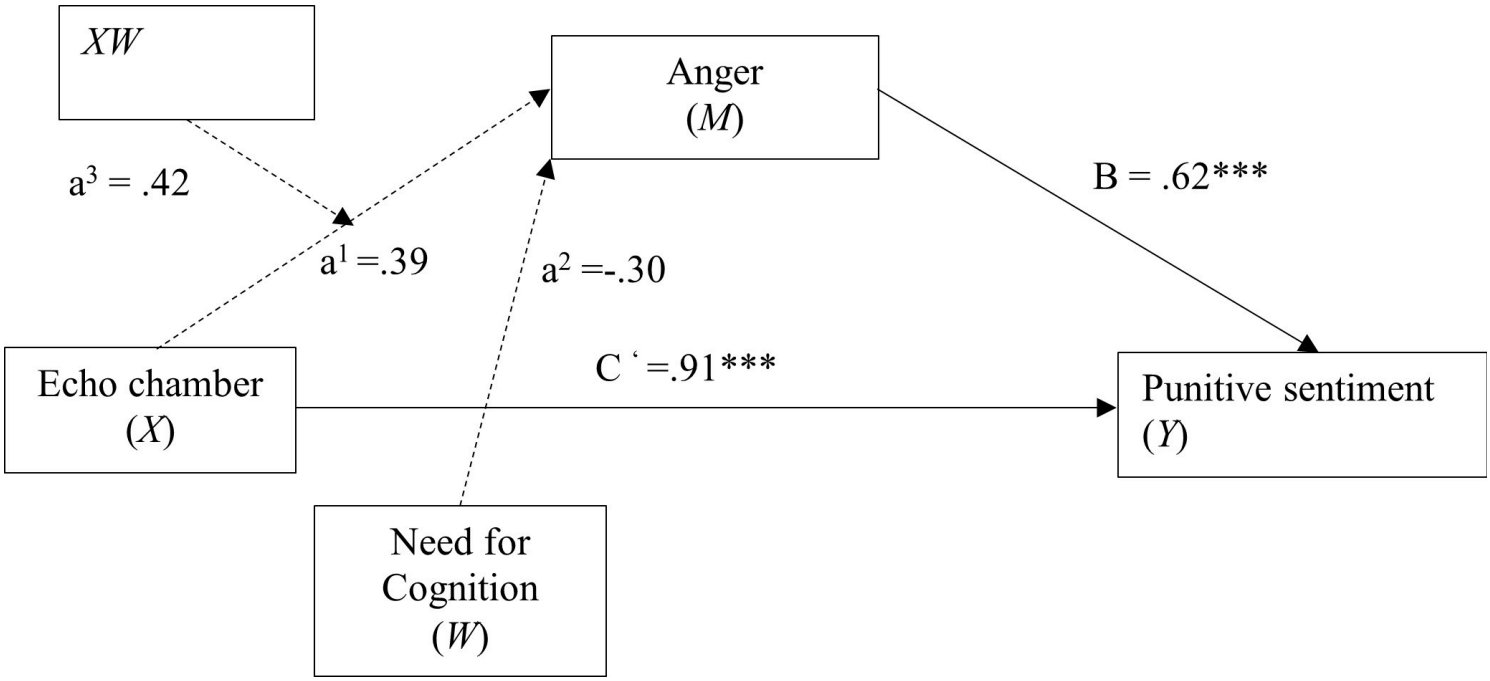


Figure 3

Statistical path Diagram of the Moderated Mediation Analysis for Need for Cognition

Note. *N* = 126. All path coefficients represent unstandardised beta coefficients. The broken line depicts non-significant relationships. *SE* = standard error. ****p* <.001.

Supplementary Files

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- AppendixA.docx