Does Cognitive Inflexibility Predict Violent Extremist Behaviour Intentions? A Registered Direct Replication Report of Zmigrod et al., 2019

Purpose: Zmigrod and colleagues (2019a) demonstrated that lower levels of cognitive flexibility predict a higher willingness to fight and die for the national ingroup. We conducted a registered direct replication of their Study 1. Extending the original study, we examined whether the documented relationship held when a self-report measure for cognitive flexibility was introduced and when identity fusion was controlled for. We also investigated if cognitive inflexibility predicts normative pro-group behaviour intentions.

Methods: Participants (N = 1378) reported in a cross-sectional survey study their willingness to fight, die, and sacrifice themselves for the ingroup and completed the Remote Associates (RAT) as well as Wisconsin Card Sorting (WCST) tests. Afterwards, self-reported cognitive flexibility, identity fusion, and normative pro-group behaviour intentions were assessed.

Results: We showed a small negative relationship between RAT accuracy rates and willingness to fight and die. WCST accuracy rates were positively related with willingness to die but not correlated with willingness to fight. Self-report measures of cognitive flexibility were partially positively and partially negatively associated with support for violent extremism. There was further evidence that lower cognitive flexibility predicts higher normative pro-group behaviour intentions. A mini meta-analysis, which synthesised findings from the original study and our replication, demonstrated a relatively small negative correlation between cognitive flexibility and support for violent extremism.

Conclusions: Even though not all individual results could be replicated, we confirmed the overall conclusion of the original study: lower cognitive flexibility predicted stronger willingness to fight and die for an ingroup. The findings highlight that it is important to integrate cognitive style in multi-level frameworks of risk factors of violent extremism. Additionally, our results point out that the validity of different measures of cognitive flexibility, including self-report tools, must be further examined. Future research that evaluates cognitive flexibility training in the context of CVE/PVE interventions is also encouraged.

Keywords: cognitive flexibility, extremist attitudes, violent extremism, direct replication

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A burgeoning body of research highlights numerous violent extremist risk factors that point, amongst others, to the role of exposure to radicalising actors, critical life events, and grievances (e.g., Bouhana, 2019; Jasko et al., 2017; Lösel et al., 2018; Obaidi et al., 2019; Perry et al., 2018; Vergani et al., 2018). Despite the breadth of this literature, the influence of cognitive processes – "mental functions … involved in the acquisition, storage, interpretation, manipulation, transformation, and use of knowledge" (American Psychological Association, 2020) – has, to date, been largely ignored. Zmigrod, Rentfrow, and Robbins' (2019a) study is one notable exception. The authors presented two cross-sectional studies, conducted in the United Kingdom and the United States, which showed that lower levels of cognitive flexibility are related to a stronger willingness to fight and die for the national ingroup.

In a field characterised as lacking sufficient empirical data (Schuurman, 2018), Zmigrod et al. s (2019a) work has the potential to advance existing lines of inquiry and inform interventions to prevent and counter violent extremism (Stephens et al., 2019). Indeed, in the year since it was published the paper has been cited already 23 times (Google Scholar citations; 29.04.21). To our knowledge, however, Zmigrod et al.'s (2019a) findings have not yet been replicated by others. Previous research that focused on the relationship between cognitive flexibility and ideological extremism (e.g., Van Hiel et al., 2010; Van Hiel & Mervielde, 2003) as well as two studies that assessed cognitive flexibility within terrorist samples (Alkhadher & Scull, 2019; Baele, 2017), in fact, obtained inconsistent results. To strengthen the contribution that the paper can make, and to address some of its limitations, we conducted a registered direct replication of Zmigrod et al. (2019a), Study 1. We complemented the hypotheses tests of the original study by examining whether result patterns

held when a self-report measure of cognitive flexibility was used, when identity fusion was introduced as a control variable, and when stricter sample exclusion criteria were applied. Moreover, we sought to assess the extent to which cognitive flexibility also predicts normative pro-group behaviour intentions.

Cognitive Flexibility and Extremism

Despite the proliferation of the literature on violent extremism in recent decades (Schuurman, 2018), implications of cognitive processes have thus far been widely neglected (for an exception see Bouhana, 2019). This is surprising, given that early work investigating predictors of *ideological extremism* focused on cognitive style, specifically cognitive flexibility. Notably, Adorno, Frenkel-Brunswik, Levinson, and Sanford (1950) showed that participants in the lower and upper quartiles on a measure of ethnocentrism were also described as less flexible in their thinking (see as well Rokeach, 1948). Cognitive flexibility is defined as the ability to adapt one's ways of thinking to changing environmental conditions (Dennis & Vander Wal, 2010). It is an executive function that relies on the processes of salience detection and attention, working memory, inhibition, and set switching (Dajani & Uddin, 2015). High cognitive flexibility may, for instance, be expressed by being able to adjust previously established habits to a new situation involving different demands (Moore & Malinowski, 2009) or by considering multiple aspects of an idea - such as rules - simultaneously (Scott, 1962). To date, it has not been definitively concluded whether cognitive flexibility is a general executive function, which is stable over time and applies to different content, or whether it is task and domain-specific (Deak & Wisehart, 2015).

Contemporary research supports the claim that cognitive flexibility is related to ideological extremism (Zmigrod, 2020). Lower levels of cognitive flexibility predict stronger right-wing attitudes (Van Hiel et al., 2016; Van Hiel et al., 2010), political conservatism (Jost et al., 2003; Sidanius, 1985), racism (Sidanius, 1985), nationalism and authoritarianism

(Zmigrod et al., 2018). Zmigrod, Rentfrow, and Robbins (2019b) also showed that those who reported being on either the extreme left or the extreme right of the political spectrum exhibited lower accuracy rates on tests that examined cognitive flexibility. That is, as documented by Ardono and colleagues (1950), attitude extremity, not partisanship, was related to stronger cognitive inflexibility (*extremism theory*; Sidanius, 1985).

Despite this compelling evidence, the literature on cognitive style and extremism is far from unanimous. Van Hiel and Mervielde (2003) demonstrated in three studies a positive - rather than negative - relationship between cognitive flexibility and ideological extremism. These results are in line with context theory (Sidanius, 1976; 1985), which argues that moderates are less flexible in their cognitive style, as they have acquired their beliefs by simply conforming to the majority. Those who endorse extreme beliefs, however, actively process and incorporate controversial ideas, thus demonstrating cognitive flexibility.

Results documenting the relationship between cognitive flexibility and violent - rather than ideological - extremism are also inconsistent. Bouhana's (2019) S5 model proposes that certain cognitive processes, including lower flexibility, contribute to individuals' susceptibility to moral change that increases the likelihood of adopting a violent extremist ideology. A study of 30 imprisoned ISIS and Al-Qaeda members in Kuwait highlighted such a correlation (Alkhadher & Scull, 2019). However, analyses of writings of 11 lone-actor terrorists, using tentative and contrary language as measures of cognitive flexibility, did not differ significantly from the writings of individuals who actively opposed the use of violence (Baele, 2017). Both studies including terrorist samples suffer limitations. Alkhadher and Scull (2019) sampled on the outcome variable 'violent extremism', which reduces the variability of the dependent measure. In addition, the measures for cognitive flexibility are in both studies arguably less than ideal. The analyses relied on informant-reports regarding the prisoners' difficulty to change their mindset or linguistic analysis of writings that may have

been affected by audience tuning. Taken in sum, the evidence base remains mixed and the relationship between cognitively flexibility and violent extremism, largely unknown.

The Original Study: Zmigrod et al., 2019a, Study 1

Addressing these challenges, Study 1 in Zmigrod et al., 2019a, provided the first systematic empirical support for a negative relationship between cognitive flexibility and violent extremist behaviour intentions. British citizens (N = 305; M_{age} = 38.02, SD_{age} = 13.51, range = 18–72; 47% female; 91% white) were recruited through the online opt-in access panel Prolific Academic. The authors operationalised cognitive flexibility as the extent to which individuals organise information in looser or more rigid semantic networks (Remote Associates Test; RAT; Mednick, 1968) and as the ability to identify, adopt, and then change rules to categorise information (Wisconsin Card Sorting Test; WCST; Grant & Berg, 1948). Violent extremist behaviour intentions were assessed with two dependent variables: willingness to die on behalf of the national ingroup, as well as willingness to sacrifice one's own life to save five British people (i.e., a trolley problem). Furthermore, the authors examined willingness to fight for the national ingroup and how certain participants were that they would indeed self-sacrifice. More detailed information about the measures is presented below.

The results showed negative correlations between RAT (r = -.241, p < .001) as well as WCST (r = -.216, p = .002) accuracy rates and willingness to fight for the ingroup. Moreover, RAT (r = -.207, p = .001), but not WCST (r = -.039, p = .587), accuracy rates were correlated negatively with willingness to die for the ingroup. Findings partially supported an indirect relation between cognitive flexibility and willingness to die. RAT (β = -.183, p = .005), but not WCST (β = -.121, p = .103), accuracy rates predicted lower willingness to fight (R^2 = .145), which, in turn, was positively associated with willingness to die for the ingroup (β = .534, p = .000; R^2 = .335). Willingness to fight for the ingroup,

however, was not related to participants' decisions in the trolley problem, such that an indirect effect could not be assessed for this alternative outcome variable. Individuals who indicated in the trolley dilemma that they would self-sacrifice rather than save themselves also did not differ in their RAT and WCST accuracy rates (WCST: $F(1, 205) = .098$, $p = .754$, RAT: $F(1, 294) = .815$, $p = .367$). Sub-group analysis showed that for participants who were willing to save the ingroup, greater conviction in the decision to self-sacrifice correlated negatively with WCST ($r = .333$, $p = .011$) and RAT ($r = .217$, $p = .034$) accuracy rates.

Proposing a Direct Replication

The aforementioned findings have important theoretical and practical implications. As the review of existing literature suggests, Zmigrod et al.'s (2019a) work serves as a much-needed steppingstone towards new lines of inquiry that incorporate cognitive style as a potential risk factor for violent extremism. The studies also introduce methods from cognitive psychology - three tasks to objectively measure cognitive flexibility - that are currently not commonly applied in violent extremism research. Crucially, the results offer relevant insights for soft power interventions that aim to prevent and counter violent extremism (PVE and CVE). One approach to PVE and CVE emphasises the importance of cognitive resources that help build resilience and reduce the risk of being attracted to or convinced by violent extremist messages (Stephens et al., 2019). To that end, cognitive complexity - overcoming "us-versus-them" and "black and white" thinking (Liht & Savage, 2013; Savage et al., 2014) - as well as critical thinking (Aly et al., 2014; Davies, 2016) are trained in educational or community settings. If evidence of the role of cognitive flexibility was strengthened, programmes could be extended to include relevant activities, such as serious gaming (Boendermaker et al., 2017), that improve adaptive decision making and thinking (Mun et al., 2017).

It is evident that Zmigrod and colleagues' paper (2019a) has the potential to impact both theory and practice. However, some concerns about the rationale, design, and results of the original study need to be explored further. First, the authors based their work primarily on previous (inconsistent) research that has focused on ideological extremism. It is not discussed how these insights apply to the study of violent extremist behavioural intentions, fighting and self-sacrificing for the ingroup. Moghaddam (2005) proposed that adopting a certain cognitive style is one of the final steps on the 'staircase' to committing a terrorist attack. But for someone to execute an attack, they must also engage with the morality of the terrorist group, categorise in- and outgroup members, and distance themselves from the outgroup (i.e., dehumanisation; see Tausch et al., 2011). Thus, the relationship between cognitive flexibility and self-sacrifice could be more complex - and weaker - than when considering prejudice or conservatism as outcome measures.

Second, partially inconsistent results were presented in Zmigrod et al., (2019a) Study 1. As described, the RAT but not the WCST accuracy rates were related to willingness to fight and die for the ingroup. The authors pointed to the moderate correlation between both measures (r = .21, p = .009) and reported an analysis that examined the unique role of WCST accuracy rates. The latter, however, did not show a statistically significant association (p = .051). Further, two of the dependent variables – a one-item self-report measure and the trolley dilemma – examined willingness to die for an ingroup. Although RAT accuracy rates were correlated with the one-item outcome measure, those who reported in the trolley dilemma that they would sacrifice their life to save ingroup members did not differ from those who would not self-sacrifice in terms of their RAT (and WCST) accuracy rates. Finally, considering findings of Study 2, which may be seen as a replication of Study 1, not all result patterns were replicated. RAT accuracy rates correlated significantly with the willingness to die in the UK but not the US sample.

Lastly, to measure violent extremist behaviour intentions, Zmigrod and colleagues used Swann and colleagues' (2009) scale, which examines willingness to fight and die for an ingroup. These two dimensions - fighting and dying - were separated such that the latter represents the outcome and the former the proposed mediator variable. Initial papers by Swann and colleagues also applied the two measures separately (e.g., Swann et al., 2009). However, in more recent publications, the two dimensions were combined into one measure, "(b)ecause the measures of willingness to fight and die are conceptually overlapping and highly correlated" (p. 828) (the concept was referred to as *endorsement of extreme actions for the group*; Gomez et al., 2011; Swann et al., 2010). In their analysis, Zmigrod et al., (2019a) did not present a factor analysis of the items capturing willingness to fight and die. Without knowing whether measures for the mediator and outcome load on the same factor, which could perhaps be expected, it is difficult to establish whether the indirect effects that were examined should indeed be computed.

The Present Research

To strengthen the conclusions presented in Zmigrod et al. (2019a) and explore the previously discussed concerns, we conducted a direct registered replication of Zmigrod and colleagues' Study 1. We also introduced additional analytical steps, and an alternative independent, control, and outcome variable. More precisely, we implemented a self-report measure of cognitive flexibility, the Cognitive Flexibility Inventory, with sub-dimensions for perceived ability to (a) control difficult situations (Control) and to (b) perceive/generate multiple alternative explanations and solutions in difficult situations (Alternatives) (CFI; Dennis & Vander Wal, 2010).

Previous research found that self-report measures of cognitive flexibility achieve higher effect sizes (van Hiel et al., 2016) and may assess a perceived need for certainty or closure instead of cognitive style (Zmigrod, 2020). The measures could also be affected by

social desirability biases (Howlett et al., 2021). We believe that it is nevertheless justified to examine the relationship between cognitive flexibility and support for violent extremism with the CFI, as well as the RAT and WCST. There exists no standard measure for cognitive flexibility. The concept has been assessed with numerous tasks, which investigate different cognitive subsystems (Gruner & Pittenger, 2017; Synder et al., 2015; Tchanturia et al., 2003; Zmigrod et al., 2019b), and several self-report scales (e.g., CFI; the Cognitive Flexibility Scale, Martin & Rubin, 1995; the Behaviour Rating Inventory of Executive Function-Adult version, Roth et al., 2005). However, the application of neuropsychological tests is less common outside the field of psychology. Researchers from other disciplines in terrorism studies may indeed be more inclined to use self-report scales that appear easier and quicker to employ (Howlett et al., 2021); they may expect that neuropsychological tests and self-report tools can be used interchangeably. We therefore aim to provide guidance for future research as to whether a negative relationship between cognitive flexibility and support for violent extremism is to be expected for both a measure like the CFI and tasks as the RAT and WCST.

Furthermore, previous research raised concerns about task impurity and the construct validity of the WCST and RAT. The WCST requires visual and numeric processing as well as the ability to process verbal feedback and maintain rules in working memory (Miyake et al., 2000; Lee et al., 2014; Nyhus & Barcelo, 2009). The RAT was developed to measure creative performance (Mednik, 1962) but assessment of its convergent validity showed positive correlations with scores on working memory tasks, processing speed tasks, intelligence tasks, and grade point average, as well as, counterintuitively, low correlations with divergent thinking measures (Lee et al., 2014). With this in mind, discrepancies in results of the WCST and RAT accuracy rates may be attributed to the fact that the tests examine different cognitive subsystems or facets of cognitive flexibility. The Alternatives

sub-scale of the CFI has been found to correlate positively with the WCST (Johnco et al., 2014). By including the CFI, we can assess whether result patterns for the Alternatives sub-scale and the WCST are comparable, which would lend tentative support to the speculation that findings of the RAT and WCST are inconsistent because the tests do not capture cognitive flexibility in the same way and degree.

We also extended the direct replication by introducing a control variable that was considered in Zmigrod et al. (2019a) Study 2 as a mediator: identity fusion. Identity fusion is defined as "a visceral sense of 'oneness' with a group and its individual members that motivates personally costly, pro-group behaviors" (Swann & Buhrmester, 2015, p. 52). Previous research consistently showed that identity fusion is related to willingness to fight and die for an ingroup (Gomez et al., 2011; Swann et al., 2009; 2010). We aimed to examine the extent to which cognitive flexibility predicts support for violent extremism over and beyond identity fusion. Additionally, we sought to assess the factor structure of the measures of willingness to fight and die for the ingroup to confirm the suitability of the indirect effect models. Lastly, we investigated whether cognitive flexibility is solely negatively associated with violent extremist behaviour intentions or whether it also predicts normative pro-group behaviour. Zmigrod and colleagues (2019a) propose that lower levels of cognitive flexibility affect support for violent extremism by strengthening ideological attachment with the ingroup. If this rationale held true, it would be expected that cognitive flexibility is also negatively related to intentions to support the ingroup through normative means, such as attending demonstrations (Simon & Klandermans, 2001).

In summary, the following hypotheses were investigated, resembling those assessed in the original study:

H1: Cognitive flexibility is negatively related to support for violent extremism.

H2: Lower cognitive flexibility predicts stronger support for violent extremism mediated by a (higher) willingness to fight for one's ingroup.

H3: Lower cognitive flexibility predicts greater conviction in one's willingness to sacrifice oneself for the ingroup.

In addition, we explored:

Research Question 1: Are willingness to fight and die unique concepts?

Research Question 2: Are the aforementioned relationships (H1-3) replicated when an additional self-report measure for cognitive flexibility is introduced?

Research Question 3: Are the aforementioned relationships (H2) replicated when controlling for identity fusion?

Research Question 4: Are the aforementioned relationships (H2) replicated when considering normative support for the ingroup as an outcome variable?

Method

The pre-registered protocol as specified in the Stage 1 submission of the direct replication as well as the data, codebook, and analytical code are available online [https://osf.io/5c36j/]. Ethical approval for the study was granted by the authors' departmental ethics committee.

Power Analysis for Confirmatory Hypothesis Testing

An a priori power analysis determined the sample size of the direct replication study. Relying on the effect sizes of the original study is not recommended when designing replication studies, as this leads to underpowered replications (Albers & Lakens, 2018; Simonsohn, 2015). We therefore first determined the smallest effect size of interest (SESOI; Lakens et al., 2018) by following Simonsohn's (2015) advice to consider the effect size that

would give the original study 33% power. The SESOI of $f^2 = 0.016$ - a small effect - was included in an a-prior power analysis for multiple regressions - $\alpha = .05$, power = .95 - which yielded a target sample size of $N = 1378$.

Participants

We recruited the target sample size of 1378 participants. Participants were on average 36.43 (*SD* = 13.37, range: 18-83) years old. 56%, were male; 43% were female, 0.8% reported non-binary gender, and 0.2% preferred not to state their gender. Most participants described their ethnicity as 'White' (86%), followed by 7% who indicated being Asian; 3% answered being of mixed, 2.6% of Black, African or Caribbean, 0.8% of Other, 0.3% of Arab, and 0.1% of Hispanic ethnicity. Participants were overall highly educated (university degree: 59%, A levels: 28%, finished compulsory schooling, including O levels: 12%, not completed compulsory schooling: 0.65%; six participants did not answer this question).

Eligibility criteria required participants to be at least 18 years old and British citizens. No quotas for socio-demographic characteristics were defined. An attention check was added, and nine participants who failed the attention check were excluded for additional analyses but not for the direct replication analyses. We had further planned to exclude participants who completed the study in less than five minutes. No participants had to be excluded based on this criterion. Missing data was not replaced at any point.

Materials

The survey was programmed using Qualtrics Survey Software. Participants reported their age, gender, ethnicity, and highest educational attainment. In line with the original study, willingness to fight for the ingroup was assessed with a five-item measure ('I would fight someone physically threatening another British person', 'I would fight someone insulting or making fun of the United Kingdom as a whole' , 'I would help others get revenge

on someone who insulted the United Kingdom', 'Hurting other people is acceptable if it means protecting the United Kingdom', 'I'd do anything to protect the United Kingdom'; 1 = *totally disagree*; 7 = *totally agree;* see Swann et al., 2009; α = .77). Participants indicated their willingness to die for the ingroup, first, by stating the extent to which they agree with the statement: 'I would sacrifice my life if it saved another group member's life' (1 = *totally disagree*; 7 = *totally agree;* see Swann et al., 2009). They were also presented with a trolley dilemma and expressed how they would behave in the following situation: 'Imagine that a runaway trolley is about to crush and kill 5 British people. You have the opportunity to jump from a bridge into the trolley's path and save all 5 British people. Would you: (a) let the trolley kill 5 British people and save your own life, OR (b) save the 5 British people and sacrifice your own life?' (Zmigrod et al., 2019a, p. 4). We then examined participants' certainty in their decision ('How certain are you that you would let the trolley crush the 5 British people and save your own life/save the 5 British people and sacrifice your own life?', 1 = *low certainty*, 100 = *high certainty*).

Cognitive flexibility was measured with the WCST and the RAT. The WCST was run through the license-free PsyToolkit (Stoet, 2010; 2017). Participants saw four cards on which different coloured geometric forms were presented. Cards varied in the colour, type, and number of geometric forms. A fifth card was presented, which had to be matched to one of the four stimulus cards. The match could be due to cards having the same number of forms, forms of the same colour, or the same forms. Participants did not know the rule for matching in advance but were given feedback after each choice. The matching rule changed after participants had correctly used a rule 10 times. All participants completed 128 trials. The RAT required participants to create words that served as a connection, or compound, for three stimulus words that are only remotely connected. For instance, the word connecting 'worm', 'shelf', and 'end' would be 'book'. We used the same problems that were used in the

original study (based on Bowden & Jung-Beeman, 2003). Participants completed 20 problems for which only a single solution was correct and were given 20 seconds for each problem. For both the WCST and RAT, accuracy rates were calculated by dividing the number of correct trials or problems by the total number of trials/problems.

Additional measures. We further included a measure of identity fusion that was used in Study 2 of Zmigrod et al., (2019a), the Dynamic Identity Fusion Index (DIFI; Jimenez et al., 2016). Participants were asked to position a small circle representing themselves in relation to a larger circle that represented the United Kingdom; the overlap between the circles reflected the extent to which the self is fused with the national identity. Distance (between circles) and overlap scores were automatically calculated by the DIFI tool.

Additionally, we used the 20-item Cognitive Flexibility Inventory (Dennis & Vander Wal, 2010; e.g., 'I have a hard time making decisions when faced with difficult situations', 'I like to look at difficult situations from many different angles', 1 = *disagree completely*; 7 = *agree completely*) as a self-report measure of cognitive flexibility. Mean scores were calculated for the two sub-scales Control (α = .89) and Alternatives (α = .91) after assessing the scale properties (see below). Control sub-scale items were reverse-coded (Supplementary Material S1) such that higher values indicated a higher tendency to perceive difficult situations as controllable. Higher scores on the Alternatives sub-scale reflected a higher ability to perceive multiple alternative explanations and generate multiple alternative solutions to difficult situations. An attention check was embedded within the items of the CFI ('This is an attention check. Please tick answer option '5' to show that you are paying attention').

Lastly, normative pro-group behaviour was examined with four items of the Activism dimension of the Activism and Radicalism Intention Scales (ARIS; 'I would donate money to an organisation that fights for my group's political and legal rights', 'I would volunteer my

time working (i.e. write petitions, distribute flyers, recruit people, etc.) for an organisation that fights for my group's political and legal rights', 1 = *disagree completely*; 7 = *agree completely;* Moskalenko & McCauley, 2009; α = .91).

Procedure

Participants were recruited via Prolific Academic. They received a wage-based payment of approximately £7/hour upon completion of the study. Eligibility criteria – being at least 18 years old and UK citizenship – were specified directly on Prolific so that only those eligible could participate. Self-report measures of willingness to fight and die were completed first, followed by the trolley problem, the RAT, and the WCST. Afterwards, participants reported demographic information. Only then were measures that were not used in the original study presented. We first introduced the CFI, including the attention check, and then assessed identity fusion as well as normative pro-group behaviour intentions.

Summary of Differences Between the Original and Replication Study

The direct replication differed from the original study only in that we used PsyToolkit to administer the WCST. Additional measures not used in the original study were presented after this point.

Determining Success of the Replication

For the outcomes of the tests of Hypotheses 1 and 3 to be considered successful replications of the original study, three criteria had to be fulfilled. First, findings that were statistically significant in the original analysis also had to achieve statistical significance in the replication ($p < .05$). Second, the direction of the correlation/group difference had to be the same in both studies. Third, the effect identified in the original study had to fall within the 95% confidence interval of the correlation coefficients of the replication analyses (Nosek et al., 2015). To determine the extent to which tests that examined Hypothesis 2 successfully

replicated the original study, we first inspected four model fit indices to conclude whether an acceptable model fit was achieved[1]: (1) the χ^2 test, (2) the RMSEA including its confidence interval (minimal acceptable score: .05 to .08), (3) the SRMR (minimal acceptable score: .05 to .10), and (4) the comparative fit index (minimal acceptable score: .95 to .97). If acceptable fit was identified, regression coefficients of the replication study were evaluated with respect to their significance, direction, and effect size (see previous criteria for Hypotheses 1 and 3).

Results

All analyses were completed with *R* 4.1.0 (R Core Team, 2019). Means and standard deviations for all continuous variables included in the original study are presented in Table 1. A total of 959 participants indicated in the trolley dilemma that they would save themselves whilst 419 participants reported their willingness to self-sacrifice.

Replication Analyses

Hypothesis 1: Cognitive flexibility is negatively related to support for violent extremism

Deviation from the pre-registration. The pre-registered analysis to test Hypothesis 1 did not include assessment of the normal distribution of continuous variables. We added this analysis for all continuous dependent variables examined in the original study to check if the data met assumptions for parametric tests. All variables failed to comply with the assumption of normal distribution (see Supplementary Material S2 for Q-Q plots, kurtosis and skewness values as well as the Shapiro-Wilk test statistics). Consequentially, non-parametric tests were chosen to assess Hypothesis 1. Specifically, Spearman instead of Pearson correlation coefficients were computed. All findings of the parametric tests are presented in Supplementary Material S3. For the test of Hypothesis 1, the conclusions of the

[1] All minimal acceptable values were confirmed by the author of the original study.

non-parametric and parametric analyses differed only with respect to one result: the correlation between 'willingness to die' and WCST accuracy rates was not significant when conducting the Pearson correlation but positive and significant when employing the Spearman correlation.

—Table 1—

Hypothesis test. In summary, Hypothesis 1 was partially supported. RAT accuracy rates were negatively correlated with both willingness to fight and die for the ingroup. However, WCST accuracy rates were positively related with willingness to die (Table 1).

Replication success. The results did not replicate the findings of the original study in their entirety (Table 3). Notably, although we showed negative associations between RAT accuracy rates and willingness to fight and die, the coefficients reported in the original study (r = -.207, p = .001; r = -.241, p < .001 respectively) were not included in the 95% confidence intervals of the correlations identified in our analyses. Further, in our study, WCST accuracy rates were not correlated with willingness to fight; the original study showed a negative correlation. WCST accuracy rates were, however, positively related with willingness to die; this association was not significant in the original study.

Hypothesis 2: Lower cognitive flexibility predicts stronger support for violent extremism mediated by a (higher) willingness to fight for one's ingroup

Testing Hypothesis 2, we investigated two path models. The independent variables were WCST and RAT accuracy rates, the mediator was willingness to fight for the group, and the dependent variables were willingness to die for the ingroup and the chosen behaviour in the trolley dilemma. Residual covariances were allowed between the independent variables. All analyses controlled for age, gender, and educational attainment, and residual covariances

were allowed between these demographic variables.[2] Model 1 included direct paths between willingness to die/trolley dilemma behaviour, willingness to fight for the group, as well as WCST and RAT accuracy rates. Model 2 specified no direct path between the independent and dependent variables. The association between WCST and RAT accuracy rates and willingness to die/trolley dilemma behaviour was to be fully mediated by willingness to fight for the group.

Deviations from the pre-registration. As the outcome variable 'willingness to die' was not distributed normally, the relevant models were estimated using maximum likelihood estimation with robust (Huber-White) standard errors and a scaled test statistic that is (asymptotically) equal to the Yuan-Bentler test statistic (i.e., MLR estimate incomplete data, given that gender data was missing for some participants). We also examined the bootstrapped solutions of test statistics but did not identify any differences. Conclusions did not differ between the parametric and non-parametric analytical approaches.

Hypothesis test. Table 2 shows that none of the models attained acceptable model fit. Therefore, Hypothesis 2 could not be assessed at this point.

Replication success. Regarding the outcome 'willingness to die', our findings did not replicate the original study as the latter achieved an acceptable model fit for the mediated model. The result pattern for the outcome variable 'choice in the trolley dilemma' replicated the original study; both studies did not attain acceptable model fit.

—Table 2—

[2] Note: for this purpose the gender variable was recoded into a dichotomous variable indicating only female or male gender: Answers that reported non-binary and 'prefer not to answer' were transformed to missing data (representing 1% of participants).

Hypothesis 3: **Lower cognitive flexibility predicts greater conviction in one's willingness to sacrifice oneself for the ingroup**

Deviation from the pre-registration. The pre-registration did not specify tests to examine the assumptions of a multivariate analysis of variance (MANOVA) that was conducted to investigate whether RAT and WCST accuracy rates differed between participants who chose to save rather than sacrifice themselves in the trolley dilemma. We added these assumption checks, assessing the homogeneity of covariance matrices and multivariate normality. Inspecting the variance-covariance matrix in each group, the homogeneity of variances and covariances was confirmed (Supplementary Material S4). However, the assumption of multivariate normality was rejected (Supplementary Material S4). Consequentially, we conducted non-parametric tests to examine Hypothesis 3. Conclusions that could be drawn from the non-parametric and parametric tests differed only with respect to the sub-group correlation analyses. Considering the Pearson but not the Spearman correlations, RAT accuracy rates were significantly related with certainty in the trolley dilemma for those who chose to sacrifice themselves (Supplementary Material S3).

Hypothesis test. In the whole sample, cognitive flexibility was not related to certainty in the decision in the trolley dilemma (Table 1). Sub-group analysis, applying Spearman correlations, demonstrated that for those who chose to save themselves, greater conviction in the decision to self-sacrifice was neither correlated with WCST (r_s = -.01, p = .666, 95% CI [-.08, .05]) nor RAT (r_s = .02, p = .580, 95% CI [-.05, .08]) accuracy rates. Likewise, for participants who indicated that they would self-sacrifice, neither RAT (r_s = -.09, p = .053, 95% CI [-.19, .05]) nor WCST accuracy rates (r_s = -.05, p = .297, 95% CI [-.15, .04] were significantly correlated with conviction in the choice in the trolley dilemma. We did, however, identify significant group differences in terms of RAT but not WCST accuracy rates (RAT: U = 173709.00, p = .000; WCST: U = 192348.00, p = .207). Participants who

indicated that they would self-sacrifice had significantly lower RAT accuracy rates (average rank save self: 717.86; average rank self-sacrifice: 624.58). The latter result offers additional support for Hypothesis 1. Hypothesis 3 was, however, rejected.

Replication success. We replicated the original study in that both analyses did not find a correlation between measures for cognitive flexibility and certainty in the decision in the trolley dilemma. Also in line with the original study, for those participants who chose to save themselves, conviction in the decision to self-sacrifice was not associated with cognitive flexibility. However, we failed to show a correlation between RAT and WCST accuracy rates and conviction in the decision in the trolley dilemma for those who indicated they would self-sacrifice. Further, the original study did not detect between-subject differences on cognitive flexibility measures, while we identified differences in terms of RAT accuracy rates.

Summary of the Replication

Table 3 summarises the outcomes of all replication analyses.

—Table 3—

Additional Pre-registered Analyses

Research Question 1

Our research also explored additional research questions beyond that of Zmigrod et al (2019a). First, we investigated whether willingness to fight and willingness to die are distinct phenomena (*Research Question 1*). We conducted a confirmatory factor analysis comparing two models: one model where all items that assessed willingness to fight and the one item that assessesed willingness to die load on one factor (Model 1), as well as a model where the latent factor willingness to fight is defined by five manifest items and correlated with the

latent factor willingness to die (Model 2).[3] Model 1 ($\chi^2(9) = 251.58$, $p = .000$; CFI = .76, RMSEA = .14 90% CI [.13, .15], SRMR = .08) did not achieve acceptable fit on all model fit indices. Model 2 was not identified. At this point, Research Question 1 could not be answered. Further exploratory analyses are presented below.

Research Question 2

Research Question 2 assessed if the relationships proposed in Hypotheses 1 to 3 (above) could be demonstrated when introducing a self-report measure for cognitive flexibility. Before conducting the additional analyses, scale properties of the Cognitive Flexibility Inventory were tested. Confirmatory factor analysis of the CFI with its two sub-scales, Control and Alternatives (Supplementary Material S1), demonstrated not fully optimal model fit (χ^2 (151) = 1565.50, $p = .000$; CFI = .89, RMSEA = .08 90% CI [.08, .09], SRMR = .09). Examining modification indices, the first two suggestions – allowing residuals of two items (CFI_8 and CFI_14) to covary and removing the first item of the Alternatives scale (Supplementary Material S1) were introduced after which model fit was satisfactory (χ^2 (133) = 1082.16, $p = .000$; CFI = .93, RMSEA = .07 90% CI [.07, .08], SRMR = .07). Mean scores of the Alternatives ($M = 5.51$, $SD = .73$) and Control ($M = 4.50$, $SD = 1.15$) sub-scales were calculated accordingly.

Re-examining Hypothesis 1.

Deviation from the pre-registration. The sub-scales of the Cognitive Flexibility Inventory did not deviate substantially from a normal distribution (Supplementary Material S2). However, as the measures for ‘willingness to fight‘ and ‘willingness to die‘ did not

[3] Deviation from the pre-registration: The measures ‘willingness to fight’ and item ‘willingness to die’ did not comply with the assumption of normal distribution. To acknowledge this, the confirmatory factor analysis was estimated using maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic (i.e., MLM estimate for complete data).

represent a normal distribution, non-parametric tests were used to explore Research Question 2.

Re-examining Hypothesis 1, Spearman correlations showed that higher Control scores were associated with a higher willingness to fight (r_s = .08, p = .003, 95% CI [.03, .13]) and die (r_s = .08, p = .003, 95% CI [.03, .13]). Higher scores on the Alternatives sub-scale predicted a lower willingness to fight (r_s = -.09, p = .001, 95% CI [-.14, -.04) and the correlation with willingness to die for the ingroup was not significant (r_s = .05, p = .051, 95% CI [.00, .11]). Moreover, pre-registered point biserial correlations between the CFI sub-scales and willingness to self-sacrifice in the trolley dilemma were not significant (Alternatives: r = .03, p = .252, 95% CI [-.02, .08]; Control: r = .02, p = .473, 95% CI [-.03, .07]). Taken together, results for the Control sub-scale partially aligned with aforementioned evidence based on the WCST accuracy rates. Results for the Alternatives sub-scale partially confirmed findings achieved using the RAT accuracy rates. Hypothesis 1 was therefore only partially supported when considering the CFI.

Re-examining Hypothesis 2.

Adding to the analysis of Hypothesis 2, we included Control and Alternatives scores as manifest independent variables in the path models. Residual covariances were allowed between the two CFI scores, WCST and RAT accuracy rates. In Model 1, additional direct paths between willingness to die/trolley dilemma behaviour, the willingness to fight for the group, as well as self-reported cognitive flexibility scores were specified. In Model 2, no direct paths were modelled between the CFI scores and dependent variables. The association between self-reported cognitive flexibility and willingness to die/trolley dilemma behaviour was to be fully mediated by willingness to fight for the ingroup.

Deviation from the pre-registration. To address the fact that the outcome measure 'willingness to die' was not distributed normally, the models were estimated using MLR estimate for incomplete data. Conclusions did not differ between the parametric and non-parametric analytical approaches.

More precisely, results showed that for the outcome variables 'willingness to die' and choice in the trolley dilemma neither Model 1 nor Model 2 provided optimal fit (Table 4). This result confirms the patterns identified when using RAT and WCST accuracy rates. Hypothesis 2 could not be tested.

Re-examining Hypothesis 3.

Next, we re-assessed Hypothesis 3, introducing the CFI. In the whole sample certainty in the trolley dilemma decision was negatively correlated with Alternatives (r_s = -.07, p = .008, 95% CI [-.12, -.02]) and positively correlated with Control (r_s = .11, p = .000, 95% CI [.06, .16]) scores. This finding partially supports Hypothesis 3. It does, however, not replicate the previously found nil correlations demonstrated between RAT, WCST accuracy rates, and conviction in one's decision. The sub-group analyses showed that for those who chose to save themselves, these relationships were also significant (Alternatives: r_s = -.09, p = .003, 95% CI [-.16, -.03]; Control: r_s = .12, p = .000, 95% CI [.06, .18]). In the sub-group that chose to self-sacrifice, only the sub-scale Control was significantly positively related with conviction in the decision in the trolley decision (r_s = .10, p = .040, 95% CI [.00, .19]) (Alternatives: r_s = .01, p = .813, 95% CI [-.08, .11]). By contrast, none of the sub-group analyses using RAT and WCST accuracy rates reached statistical significance.

*Deviation from the pre-registration***.** We then examined assumptions for the MANOVA, including the sub-scales of the CFI as dependent variables. Homogeneity of variances was not rejected but multivariate normality could not be attained. We, therefore,

conducted non-parametric tests for these additional analyses. The conclusions that could be drawn from the parametric and non-parametric analyses did not differ.

We identified no difference for either outcome variable (Alternatives: U = 194573.00, p = .351; Control: U = 196805.00, p = .546) between participants who indicated that they would self-sacrifice vs. save themselves in the trolley dilemma. This latter result is in line with the results shown for WCST but not the evidence for RAT accuracy rates.

Research Question 3

Research Question 3 explored whether Hypothesis 2 was supported when identity fusion was included as a control variable. Therefore, in the models that assessed Research Question 2 we also introduced direct paths between identity fusion (overlap score) and the two outcome variables; residual correlations were allowed between identity fusion and willingness to fight. Neither model achieved satisfactory model fit and this research question could not be examined at this point (Table 4).

Research Question 4

Finally, *Research Question 4* investigated the extent to which cognitive flexibility also predicted normative pro-group behaviour. First, a confirmatory factor analysis was completed for the items of the ARIS activism sub-scale, with all four items proposed to define one factor[4]. Model fit was acceptable ($\chi^2(2)$ = 13.37, p = .001; CFI = .99, RMSEA = .09 90% CI [.05, .14], SRMR = .01) and one mean score was computed (M = 2.84, SD = 1.39).

[4] Deviation from the pre-registration: As shown below (Additional Analyses Hypothesis 1), the ARIS scale did not comply with the assumption of normal distribution. To acknowledge this, the confirmatory factor analysis was estimated using maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic (i.e., MLM estimate for complete data).

Deviation from the pre-registration. Tests of normal distribution showed that the ARIS scale could not be considered normally distributed. The respective models were therefore estimated using MLR estimates for incomplete data. Conclusions did not differ between the parametric and non-parametric analytical approaches.

In the next step, we assessed Model 1 and 2 as described in the original study as well as the extended Model 1 and 2 (including the CFI and identity fusion as additional independent and control variables) by considering normative pro-group behaviour intentions as the outcome variable. Neither Model 1 nor Model 2 provided optimal fit (Table 5). Spearman correlations, however, showed that normative pro-group behaviour was significantly negatively correlated with RAT (r_s = -.07, p = .007, 95% CI [-.13, -.02]) but not WCST accuracy rates (r_s = -.000, p = .971, 95% CI [-.05, .05]). This result replicated the relationships found between RAT accuracy rates and willingness to fight and die.

—Table 4—

—Table 5—

Robustness test

The original study did not report using an attention check. We, therefore, added an analysis of all pre-registered tests with a sample where nine participants who failed an attention test were excluded. No differences in overall result patterns were identified between the full and reduced sample (Supplementary Material S5).

Exploratory Analyses

Several models of the pre-registered analyses did not attain satisfactory fit or were not identified. We conducted further exploratory analyses to address these issues. Notably, to investigate Hypothesis 2, we explored the modification indices for Model 1 of the original

study to detect additional covariances that could improve model fit[5]. Two covariances – between residuals of RAT accuracy rates and level of education as well as RAT accuracy rates and age – were proposed. Introducing these covariances, the model fit improved but remained not fully acceptable due to the sub-optimal comparative fit index ($\chi^2(9) = 118.77$, $p = .000$; CFI = .81, RMSEA = .09 90% CI [.08, .11], SRMR = .06). We then re-examined the mediated model by adding the same two covariances; as for Model 1, model fit improved but was once more not acceptable ($\chi^2(9) = 123.94$, $p = .000$; CFI = .80, RMSEA = .10 90% CI [.08, .11], SRMR = .06).

Next, we re-assessed the scales that were introduced to measure willingness to fight and die for the ingroup. Inspecting the modification indices for a model where all six items of willingness to fight and die loaded on one latent factor, covariances between the residuals of six items (Figure 1) were specified. Introducing these modifications, model fit was acceptable ($\chi^2(4) = 16.06$, $p = .003$; CFI = .99, RMSEA = .05 90% CI [.03, .07], SRMR = .02). After we introduced the same modifications for an alternative model that distinguished willingness to fight and die as in the original study, the model remained unidentified. In response, we fixed the loading of the latent factor 'willingness to die', which still resulted in a not positive definite covariance matrix. Covariances that had been initially introduced were dropped sequentially, starting with those that would improve model fit the least. Model fit could be estimated once all but one covariance (between item two and three) were removed. The subsequent model fit was not fully acceptable as the RMSEA score was slightly too high ($\chi^2(8) = 121.39$, $p = .000$; CFI = .89, RMSEA = .10 90% CI [.09, .11], SRMR = .05). Notably, the model comparison test was significant ($\chi^{2diff}(4) = 105.25$, $p = .000$) and suggested better fit of the parsimonious model that proposes one factor, defined by all six

[5] Considering the MLR or MLM estimates to acknowledge that the outcome measure was not distributed normally.

items that assess willingness to fight and die. Given the various modifications required to estimate model fit, this conclusion should be taken cautiously.

—Figure 1—

Nevertheless, we performed an exploratory analysis in which a new variable – willingness to fight/die (α = .78) – was introduced as the outcome variable, to be predicted by RAT and WCST accuracy rates, controlling for demographic variables. Once more model fit was sub-optimal considering the comparative fit index ($\chi^2(6) = 76.15$, $p = .000$; CFI = .69, RMSEA = .09 90% CI [.07, .11], SRMR = .05). As previously, we inspected modification indices, and covariances between RAT accuracy rates and age as well as level of education were proposed. Introducing this additional specification, acceptable model fit was achieved ($\chi^2(4) = 18.22$, $p = .001$; CFI = .94, RMSEA = .05 90% CI [.03, .08], SRMR = .02). This model also presented a significantly better fit than the Model 1 proposed in the original study (when adding covariances between RAT accuracy rates and age as well as level of education; χ^2diff (5) = 96.50, $p = .000$). The regression coefficients support the conclusions of the original study: lower cognitive flexibility as measured by RAT accuracy rates, but not WCST accuracy rates, were related with higher violent extremist behaviour intentions. The explained variance of the outcome was 7% (Figure 2).

—Figure 2—

Lastly, we inspected modification indices for the model that tested whether cognitive flexibility predicted normative pro-group behaviour intentions. Once again, covariances between the residuals of RAT accuracy rates and age as well as level of education were proposed. The highest improvement in model fit was, however, achieved by regressing willingness to fight on gender. This adapted model attained acceptable fit ($\chi^2(8) = 39.44$, p = .000; CFI = .92, RMSEA = .05 90% CI [.04, .07], SRMR = .03). RAT accuracy rates were

negatively related to the willingness to engage in normative pro-group behaviour. The explained variance of the outcome variable was 11% (Figure 3).

—Figure 3—

Synthesising All Results

The main aim of this study was to present a direct replication of Zmigrod and colleagues' (2019a) Study 1. In the previous sections, we highlighted hypothesis tests that did, or did not, achieve findings that replicated the original study. While important, assessing the successful replication of individual results alone inadvertently pits the replication against the original study. To emphasise how our study and Zmigrod and colleagues' (2019a) work can be synthesised, we conducted a fixed effects mini meta-analysis of three data points: (a) the average of Spearman correlations between RAT and WCST accuracy rates, as well as Alternatives and Control CFI sub-scales and willingness to fight as well as willingness to die as identified in our study (r = -.04, N = 1378), (b) the average of correlations between RAT and WCST accuracy rates and willingness to fight as well as willingness to die as identified in Study 1, Zmigrod et al. (2019a; r = -.18, N = 304) and, (c) the average of correlations between RAT and WCST accuracy rates as well as Alternative Uses Test accuracy rates and willingness to fight as well as willingness to die as identified in Study 2, Zmigrod et al. (2019a; r = -.12, N = 743). A mean correlation of r = -.08, 95% CI [-.12, -.04] pointed to a relatively small negative association between cognitive flexibility and violent extremist behaviour intentions.

Discussion

We conducted a registered direct replication of Zmigrod et al. (2019a) Study 1, examining cognitive inflexibility as a risk factor for violent extremism. Although we did not replicate all results of the original study, several of our findings support its overall conclusion: lower levels of cognitive flexibility were weakly correlated with a higher willingness to fight and die for an ingroup. Below, we discuss the implications as well as limitations of the present research, including suggestions for future studies.

Integrating Cognitive Flexibility in Multi-level Models of Risk Factors of Violent Extremism

We showed negative correlations between RAT accuracy rates and willingness to fight and die. Furthermore, the mini meta-analysis, a synthesis of several findings in the original and replication study, pointed to a negative correlation between cognitive flexibility and support for violent extremism. It must be acknowledged that these effects were relatively small. Indeed, it is not unusual that effect sizes of replications are lower than those of original studies (Nuijten et al., 2015). And in psychology as well as research that examines risk factors of violent recidivism, small to moderate effect sizes are generally fairly common (BLINDED; Richard et al., 2003). Importantly, Funder and Ozer (2019) argued that small effects could cumulate over time, thus increasing their impact. We therefore believe that our findings, despite the small effect sizes, justify that cognitive style is considered as a further potential risk factor of violent extremism.

A valuable next step would then be to integrate cognitive flexibility in a multi-level model of risk factors of violent extremism. Bouhana's (2019) S5 model is a suitable framework. Specifically, S5 would postulate that low levels of cognitive flexibility likely predict stronger support for violent extremist action if individuals are exposed to radicalising

settings (i.e., settings where radicalising actors are present, where access to those actors is possible, and where informal control is low) that emerge in a social ecology that is, for instance, defined, by societal segregation or low levels of intergroup contact. Future research should empirically assess these conjectures to provide a deeper understanding as to when cognitive flexibility can facilitate violent extremist intentions and behaviours. Building on previous work in criminology, such studies could capture information about individuals' immediate activity field (i.e., using small-area community surveys or assessing space-time budgets; Wikström et al., 2012) and rely on Census or other official data that describes larger geographical entities as proxy measures for social-ecological factors. Multi-level modelling (Snijders & Bosker, 2011) can then be applied to test direct and moderated relationships between factors on different levels of analysis. More broadly speaking, we encourage researchers to continue to advance the assessment of individual-level risk factors and additionally include meso- and macro-level variables (i.e., variables that define the groups/settings/environments where individuals navigate their lives). Studies that investigated the 3N model (Kruglanski et al., 2019), although not necessarily testing multi-level models, provide examples for such work that considers, among others, the peer or social network in which individuals are embedded (Belanger et al., 2020; Jasko et al., 2019; Lobato et al., 2021).

Cognitive Flexibility and Support for Normative Pro-group Behaviour

Our findings further highlighted that lower cognitive flexibility, as measured by RAT accuracy rates, was related to a higher willingness to engage in *normative* pro-group behaviour, such as attending demonstrations or making donations for a group. Given that this negative association was only identified in exploratory tests, which required the introduction of additional model specifications, replications of the analysis are clearly required. Nevertheless, it is worthwhile to consider how this result could be explained, given the

previously shown negative relationship between cognitive flexibility and willingness to fight and die for the ingroup. Extremism theory (Sidanius, 1985) argued that lower cognitive flexibility is associated with stronger ideological convictions; this applies to those on the extreme left and extreme right of the political spectrum (Zmigrod et al., 2019b) and can manifest in a stronger national identity (Zmigrod et al., 2018a) as well as stronger party identification (Zmigrod et al., 2018b). In other words, lower levels of cognitive flexibility appear to be related with a higher willingness to adopt collective identities and take collective action – be it through violent or normative means.

This observation, if confirmed in future studies, opens different avenues for research. On the one hand, the result suggests that studies and theoretical frameworks that seek to predict collective action intentions (e.g., Tausch & Becker, 2013; van Zomeren et al., 2008) should be extended to also include cognitive style as a predictor. On the other hand, research must further explore when, and, under what conditions, cognitive inflexibility is a risk factor for violent, rather than normative, behaviour on behalf of an ingroup. Returning to the S5 model (Bouhana, 2019), one possible moderating factor that could be examined is exposure to peers or information that promotes the use of violence (rather than normative means) to attain group goals.

Measuring Cognitive Flexibility

Different tasks and self-report measures are available to assess cognitive flexibility (Dennis & Van der Wal, 2010; Gruner & Pittenger, 2017; Martin & Anderson, 1998; Synder et al., 2015; Tchanturia et al., 2003). Zmigrod et al. (2019a) relied on the RAT, WCST, as well as the Alternative Uses Test (in Study 2). We introduced an additional self-report measure, notably because we believed that other researchers who are not familiar with neuropsychological tasks might be drawn to the latter. Our results indicated that, depending

on which operationalisation is chosen, the relationship between cognitive flexibility and support for violent extremism is positive, negative, or non-significant. For instance, while RAT accuracy rates were negatively correlated with willingness to fight and die for the ingroup, WCST accuracy rates correlated positively with willingness to die. Moreover, the CFI sub-scales were positively and negatively related with the outcomes. Associations between conviction in the decision in the trolley dilemma and both CFI sub-scales were (positively and negatively) significant, whereas RAT and WCST accuracy rates failed to predict this dependent variable (in the overall sample). Lastly, result patterns of the two neuropsychological tasks were not consistently replicated when considering the alternative self-report CFI.

Taken together, these observations raise two points. First, the inconsistent results of the CFI, RAT and WCST confirm evidence of previous work on ideological extremism (e.g., Van Hiel et al., 2010; Van Hiel & Mervielde, 2003). Importantly, a recent meta-analysis showed no relationship between various self-report and neuropsychological measures of cognitive flexibility (Hewlett et al., 2021). In other words, self-report scales and neuropsychological tasks that aim to assess cognitive flexibility cannot be used interchangeably. Unfortunately, we are not in the position to guide researchers with respect to which measure is ideal. Neuropsychological tasks certainly avoid many of the limitations of self-report tools. However, as RAT and WCST accuracy rates were negatively, positively, or not at all related with the outcome measures, it is evident that the validity of these tasks remains to be confirmed. It is, for instance possible that the tasks capture different facets of cognitive flexibility. Eslinger and Grattan (1993) distinguished reactive or spontaneous flexibility and assessed the latter with the WCST. The RAT might be considered an assessment of “the ready flow of ideas and answers, often in response to a single question[,] [e]ncompassing the notion of ‘fluency’” (p. 18). Additionally, the RAT and WCST assess

multiple cognitive systems (task impurity; Miyake et al., 2000; Lee et al., 2014). Given the open questions surrounding the validity of the neuropsychological tasks, Hewlett and colleagues (2021) point out that perhaps the broad term 'cognitive flexibility' should not be used. Instead a more specific terminology that reflects the chosen assessment method, and what it captures, could be introduced.

Alternatively, the discrepancy of findings pertaining to the RAT and WCST accuracy rates might also be due to how we scored the WCST. Performance in the WCST can be scored in several ways (Miles et al., 2021). In line with the original study, we calculated an overall success score (number of correct trials divided by the total number of trials). A more common approach, that has been recommended to assess cognitive flexibility (Miles et al., 2021), considers instead perseverative responses and errors. The latter refer to wrong decisions in the WCST, for instance, matching cards based on the colour of the forms, despite having previously received the feedback that this rule is incorrect. Unfortunately, the automated scoring of the WCST that we used did not allow us to re-examine the analyses with indicators of perseverative errors. Following Miles and colleagues' (2021) suggestion, we would however encourage others to capture perseverative responses and errors of the WCST.

Practical Implications

A key motivation for conducting a direct replication of Zmigrod and colleagues' (2019a) work was the potential for drawing practical implications. Notably, and as reflected on earlier, if cognitive inflexibility was to be confirmed as a risk factor for violent extremism, relevant interventions for P/CVE programmes could be suggested. Our research offers overall support for the claim that cognitive flexibility is negatively related with willingness to fight and die for the ingroup. We nevertheless believe that further studies are required to

strengthen the evidence basis that could then inform practice. Notably, given the small effect size that we identified, it must be considered whether efforts that target only cognitive flexibility are cost-effective (see the EMMIE framework as a guidance for how to address economic costs in an evaluation framework; Johnsons et al., 2015). It is more likely that such training (that has been applied in clinical contexts, Boendermaker et al., 2017), would complement other efforts, especially those that prevent exposure to radicalising settings. As a first step towards defining concrete recommendations for practitioners, we propose further direct or conceptual replications of Zmigrod and colleagues (2019a) as well as evaluation studies of cognitive flexibility training with respect to outcomes that assess support for violent extremism.

Limitations

The aforementioned conclusions must be considered in light of the following limitations. Notably, the path models that were examined in the pre-registered analyses did not achieve suitable fit until additional specifications were introduced, informed by modification indices. These exploratory steps extended the insights we could gain from the data. For example, the mediated model that was shown in the original paper - cognitive flexibility predicting willingness to die through willingness to fight - did not achieve acceptable fit. After examining the factor structure of the mediator and dependent variable, one overarching outcome was computed (Gomez et al., 2011; Swann et al., 2010). Once additional covariances were introduced, we showed that lower cognitive flexibility as measured by the RAT predicted higher violent extremist behaviour intentions. In other words, we had to employ numerous degrees of freedom (Wicherts et al., 2016) in the analytical phase to arrive at a suitable model. Deviation from a pre-registration is always possible, and often required. Testing these adapted models with new data would however strengthen the implications that can be drawn.

Moreover, we recognise that it could have been helpful to add not only a self-report measure of cognitive flexibility but also a further neuropsychological task such as the Trail Making Test (Reitan, 1958), another commonly used task to assess cognitive flexibility. Doing so, we could draw broader conclusions about the variety of result patterns that can be achieved with various tests. Relatedly, specification curve analysis could prove useful to address the concern that we employed various analytical strategies to examine the research question. As our data set is publicly available, we encourage other researchers to pursue the relevant analysis.

Despite these challenges we believe that this direct replication study makes an important contribution to the literature. We conclude, as documented in the original study, a negative relationship between cognitive flexibility and support for violent extremism. Our results open avenues for future research, theory, and practice. Notably, we confirm that cognitive style can be a pertinent risk factor for violent extremism. Specifying the conditions under which cognitive inflexibility facilitates violent rather than normative behaviour intentions as well as refining the measures to assess cognitive flexibility are crucial next steps in this line of research.

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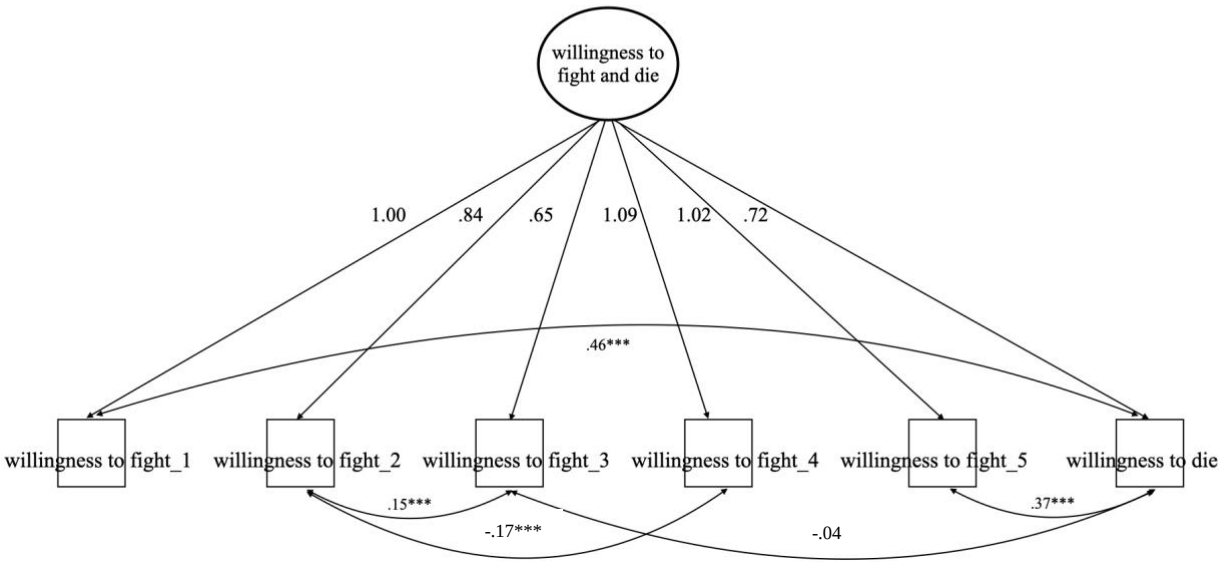
Figures and Tables

Figure 1

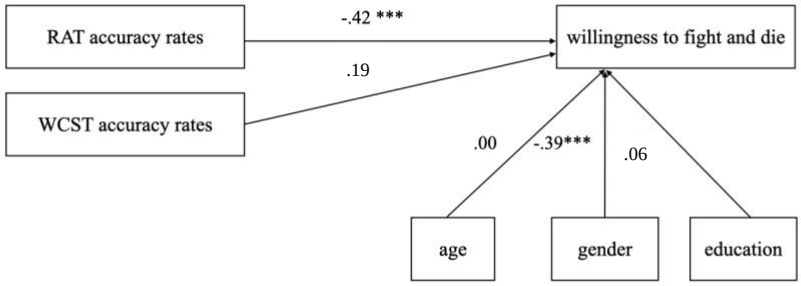
Results of the confirmatory factor analysis: willingness to fight and die



Note. *** $p < .001$

Figure 2

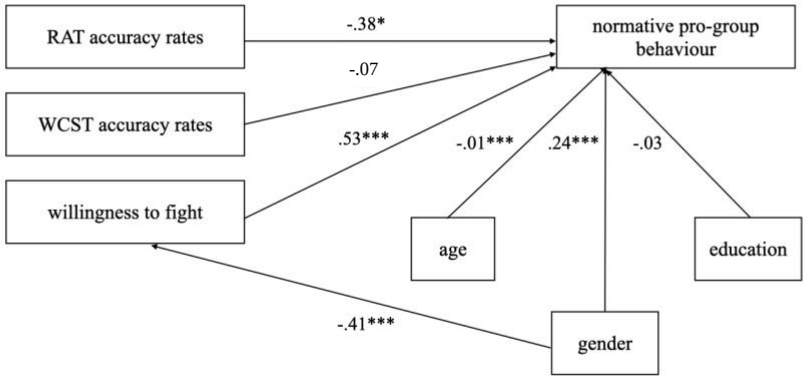
Path model: cognitive flexibility as a predictor for willingness to fight and die



Note. *** $p < .001$

Figure 3

Path model: cognitive flexibility as a predictor for normative pro-group behaviour



Note. * $p < .05$, *** $p < .001$

Table 1

Descriptive statistics and Spearman correlations (95% CI are presented in brackets)

Variable	M	SD	1	2	3	4	5
1 -Willingness to die	2.32	1.49	1				
2 - Willingness to fight	1.75	0.82	.50*** (.45, .53)	1			
3 - Certainty trolley dilemma	62.91	28.31	-.24*** (-.29, -.19)	-.05 (-.10, .01)	1		
4 - RAT	0.57	0.20	-.08*** (-.14, -.03)	-.08*** (-.14, -.03)	.02 (-.04, .07)	1	
5 - WCST	0.79	0.10	.07* (.02, .12)	.01 (-.04, .07)	-.01 (-.06, .04)	.22*** (.17, .27)	1

Note. *** $p < .001$, * $p < .05$

Table 2

Model fit indices to test Hypothesis 2

Fit index	Outcome: Willingness to die	Outcome: Willingness to die	Outcome: Choice trolley dilemma	Outcome: Choice trolley dilemma
	Model 1	Model 2	Model 1*	Model 2*
χ^2 test	$\chi^2(11) = 175.25$, $p = .000$	$\chi^2(11) = 181.11$, $p = .000$	$\chi^2(4.64) = 77.83$, $p = .000$	$\chi^2(10) = 214.79$, $p = .000$
CFI	0.71	0.70	0.51	0.39
RMSEA [90% CI]	.10 [.09, .12]	.11 [.09, .12]	N/A	.12 [.11, .14]
SRMR	0.07	0.07	0.06	0.07

Note. * = Model was not identified.

Table 3

Summary of outcomes of replication analyses

Hypothesis	Result original study	Result replication analysis	Replication success and reason for failed replication
Cognitive flexibility is negatively related to support for violent extremism.	RAT accuracy rates are negatively correlated with willingness to fight	RAT accuracy rates were negatively related to willingness to fight	no effect sizes were lower
	WCST accuracy rates are negatively correlated with willingness to fight	WCST accuracy rates were not related with willingness to fight	no relationship was non-significant
	RAT accuracy rates are negatively correlated with willingness to die	RAT accuracy rates were negatively related to willingness to die	no effect sizes were lower
	WCST accuracy rates are not correlated with willingness to die	WCST accuracy rates were positively associated with willingness to die	no direction of relationship was reversed
Lower cognitive flexibility predicts stronger support for violent extremism mediated by a (higher) willingness to fight for one's ingroup.	For the outcome 'willingness to die': A mediated model provides better fit than a model that proposes direct relations between cognitive flexibility and the outcome.	None of the models for the outcome 'willingness to die' achieved fully acceptable fit.	no model fit not acceptable
	For choice in the trolley dilemma: No acceptable model fit is identified.	Model fit for the outcome 'choice in trolley dilemma' was not acceptable.	yes

Lower cognitive flexibility predicts greater conviction in one's willingness to sacrifice oneself for the ingroup.	RAT and WCST accuracy rates are not correlated with conviction to self-sacrifice	RAT and WCST accuracy rates were not correlated with conviction to self-sacrifice	yes
	No difference in RAT accuracy rates between individuals who indicated that they would self-sacrifice vs. save themselves in the trolley dilemma	Difference in RAT accuracy rates between those who chose to safe themselves or self-sacrifice	no attained significant group differences
	No difference in WCST accuracy rates between individuals who indicated that they would self-sacrifice vs. save themselves in the trolley dilemma	No difference in WCST accuracy rates between those who chose to safe themselves or self-sacrifice	yes
	In group that would self-sacrifice: negative correlation between conviction to sacrifice and RAT as well as WCST accuracy rates	In group that would self-sacrifice: cognitive flexibility was not associated with conviction to self-sacrifice	no relationship was non-significant
	In group that would save themselves: no correlation between conviction in choice in trolley dilemma and cognitive flexibility	In group that would save themselves: no correlation between conviction in choice in trolley dilemma and cognitive flexibility	yes

Table 4

Model fit indices for analyses of Research Question 2, Hypothesis 2

Fit index	Outcome: Willingness to die	Outcome: Willingness to die	Outcome: Choice trolley dilemma	Outcome: Choice trolley dilemma
	Model 1	Model 2	Model 1*	Model 2*
χ^2test	$\chi^2(26) = 398.98$, p = .000	$\chi^2(26) = 408.52$, p = .000	$\chi^2(25) = 469.62$, p = .000	$\chi^2(25) = 449.13$, p = .000
CFI	0.61	0.60	0.36	0.39
RMSEA (90% CI)	.10 [.09, .11]	.10 [.10, .11]	.12 [.11, .12]	.11 [.10, .12]
SRMR	0.07	0.07	0.08	0.08

Note. * = Model was not identified.

Table 5

Model fit indices for analyses of Research Question 4

Fit index	Outcome: Normative pro-group behaviour	Outcome: Normative pro-group behaviour	Outcome: Normative pro-group behaviour	Outcome: Normative pro-group behaviour
	Model 1 (original)	Model 2 (original)	Model 1 (adaption)	Model 2 (adaption)
χ^2 test	$\chi^2(11) = 175.24$, $p = .000$	$\chi^2(11) = 171.90$, $p = .000$	$\chi^2(26) = 399.02$, $p = .000$	$\chi^2(26) = 395.51$, $p = .000$
CFI	0.56	0.57	0.51	0.52
RMSEA (90% CI)	.10 [.09, .12]	.10 [.09, .12]	.10 [.09, .11]	.10 [.09, .11]
SRMR	0.07	0.06	0.07	0.07