Youth misuse of fire: measuring the risk of firesetting behaviour using explicit and implicit methods

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Youth Misuse of Fire: Measuring the Risk of Firesetting Behaviour Using Explicit and Implicit Methods

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Abstract

Accelerated shifts in global climate have increased the threat from intentionally lit fires, especially within wildfire prone communities. A considerable proportion of intentionally lit fires are set by adolescents with high levels of fire interest. A persistent issue within the literature is difficulty with reliably assessing fire interest, as existing self-report measures are highly susceptible to censored responses. The current study investigated whether fire interest could be effectively measured using attentional bias tasks. The sample consisted of 86 participants (10–17 years; M = 13.65, SD = 1.81) allocated into three firesetter classifications: minor firesetter (n = 24), serious firesetter (n = 28), and non-firesetter (n = 34). All participants completed a series of questionnaires and two modified Stroop tasks aimed at measuring implicit fire interest. The findings showed no association between explicit and implicit measures of fire interest. However, serious firesetters scored significantly higher than other firesetter classifications on both explicit and implicit measures. Additionally, both explicit fire interest and performance on the Lexical Fire-Stroop emerged as significant predictors of firesetting behaviour. Collectively, these results illustrate the Stroop paradigm may be an effective tool to measure implicit fire interest within a community sample, and potential improvements are discussed. The current study detected a surprisingly high frequency of self-reported firesetters within a community sample and significant incongruency between parental and child reported firesetting behaviour, demonstrating the importance of continued research in this area.

Keywords Firesetting · Fire Interest · Child and Adolescent · Antisocial behaviour · Implicit Assessment · Stroop

Shifts in global climate have increased the frequency and intensity of extreme weather events which can have catastrophic consequences (Stott, 2016). Wildfires have become an ever-growing threat as many communities around the globe reside near fire-prone regions (Sun et al., 2019). The destructive potential of these fires was illustrated during the record-setting 2020 California Wildfire season, which resulted in an estimated $130 billion in damages (Roman et al., 2020). An unfortunate reality is that some of these destructive and deadly fires are deliberately set. Deliberate firesetting represents a significant, preventable concern impacting communities, destroying land and property, and costing nations billions of dollars each year (Bell et al., 2018). Across the world, youth make up a large proportion of firesetters. In the United Kingdom and North America, 40 and 50% of people respectively cautioned or arrested for firesetting are aged under 18 (Hoerold & Tranah, 2014; MacKay et al., 2012). A similarly high prevalence has been reported in New Zealand, with 50% of deliberately lit fires in 2016/17 set by young people aged under 17 (Lambie et al., 2019). Despite their scale, these figures likely underrepresent the scope of the problem, with this complex behaviour proving difficult to detect (Lambie & Randell, 2011; Pooley & Ferguson, 2017). For example, in a community sample of nearly 4000 Canadian youth, 70% admitted to setting something on fire in their lifetime (MacKay et al., 2009), which suggests many firesetting incidents by young people remain officially unknown. Given the potential cost of fire damage to individuals and communities, and the elevated official and unofficial rates of young people engaging with fire, further investigation to aid in prevention efforts is imperative.

'Youth misuse of fire' (YMF) is an umbrella term that encapsulates all youth-related fire incidents, spanning the

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spectrum from those considered minor to severe (Pooley & Ferguson, 2017). Some have argued that youth engagement with fire is developmentally normal (Kennedy et al., 2006; Lambie et al., 2002). Fire interest develops by about age five and remains largely an interest until age 12, before an increase in experimentation with fire becomes more manifest between ages 13 and 16 (Pooley & Ferguson, 2017). Given the dangers presented by fire, all youth engagement with fire is cause for concern (Pooley & Ferguson, 2017). There are some individual (e.g., gender), environmental (e.g., familial circumstances), and fire specific factors (e.g., fire interest) that increase the risk of YMF (Ellithy et al., 2021). Successfully measuring risk is essential for prevention and early intervention efforts. Unlike individual and environmental risk factors, which are largely observable, fire-specific factors can be difficult to accurately measure (Gallaher-Duffy et al., 2009).

Fire interest has been identified as one of the strongest predictors of YMF (Barrowcliffe et al., 2019; Lambie et al., 2019; Pooley & Ferguson, 2017). Significant differences in fire interest levels exist between firesetters and non-firesetters (Barrowcliffe & Gannon, 2016; Gannon et al., 2013), and increased fire interest distinguishes between youth who have set one or two fires, and those who have lit three or more fires (Watt et al., 2015). The level of fire interest has also been used to successfully predict future firesetting (Watt et al., 2015), and a positive relationship exists with fire interest and fire severity (MacKay et al., 2012). Given these findings, measuring the fire interest levels of youth firesetters is a useful step in addressing the behaviour (Dadswell et al., 2021). At present, fire interest is predominantly measured via parent or self-report survey (Gallagher-Duffy et al., 2009). These explicit measures are susceptible to social desirability bias (King & Bruner, 2000) with potential impacts on the validity of findings. Further issues identified with explicit measures of fire interest are discrepancies between individuals in interpretation of items, language comprehension, and willingness to respond (Gallagher-Duffy et al., 2009). An implicit measure of fire interest would avoid these issues, but only limited research has explored the utility.

In a seminal study, Gallagher-Duffy et al. (2009) used a modified pictorial Stroop to assess implicit fire interest. The Stroop is a widely used information-processing task within the field of cognitive psychology, however it has also been presented as a useful measure of attentional bias (Toh et al., 2017). Adolescent firesetters were found to have significantly slower response times and reduced accuracy compared to a control group when fire stimuli were presented during a pictorial Stroop task, with a moderate effect size reported (Gallagher-Duffy et al., 2009). The researchers theorised these results were due to increased fire interest within the firesetter sample, with the presentation of fire-related stimuli distracting participants in this group from the requirements of the Stroop task. Interestingly, they found a positive relationship between self-reported firesetting frequency and reaction time interference from fire-related stimuli (i.e., attentional bias), but a negative relationship between self-reported fire interest and attentional bias on the pictorial Fire-Stroop. This indicates that those demonstrating high fire interest on the implicit measure through increased reaction time for fire-related stimuli were self-reporting low fire interest, but contradictorily this increased implicit bias towards fire-stimuli was related to more firesetting behaviour.

Only one other study (Hoerold & Tranah, 2014) is known to have used a modified Stroop task to examine fire interest implicitly. However, in contrast to Gallagher-Duffy et al. (2009), a Lexical Fire-Stroop task (rather than pictorial Stroop task) was used in conjunction with measures of self-reported fire interest. Hoerold and Tranah (2014) found no significant difference between adolescent firesetters and a control group on reaction time or accuracy on the Stroop task, conflicting with previous findings from Gallagher-Duffy et al. (2009). Interestingly, a weak significant negative relationship was observed between self-reported fire interest and accuracy on the fire-related words for the Stroop task. This finding tentatively supports the notion that the modified Stroop task implicitly measures fire interest, as participants who reported higher levels of fire interest were less accurate in their Stroop responses, presumably due to being distracted by the highly salient fire-related words. However, this finding partially conflicts with Gallagher-Duffy's (2009) results where during the presentation of fire-related stimuli increased distractibility (measured in reaction time rather than accuracy) was documented in participants with lower, not higher, fire interest.

Importantly, the only two studies to use a modified Stroop for measuring fire interest used different paradigms, one lexical, and the other pictorial (line drawings). In their meta-analysis of 16 neuroimaging studies using the emotional Stroop, Song and colleagues (2017), identified three types of emotional Stroop tasks. Type one involves participants identifying the ink colour of emotionally-salient and emotionally-neutral words, similar to Hoerold and Tranah (2014). Type two emotional Stroop tasks modify the original version with positive and negative facial expressions. This version has not been adapted to measure implicit fire interest. Lastly, type three emotional Stroop tasks are akin to Gallagher-Duffy (2009), and present participants with emotionally-salient and emotionally-neutral images. Crucially, type one produces mild emotional interference compared to type two and three, and show different patterns of cortical activation (Song et al., 2017), which likely

contributed to the conflicting findings from Gallagher-Duffy (2009), and Hoerold and Tranah (2014). It is important to note that contrary to most pictorial emotional Stroop tasks, Gallagher-Duffy's (2009) decision to use line-drawings may have impacted results. Research shows increased emotional responses to real-world images compared to drawings (Yang et al., 2019). Further, recall and recognition were shown to significantly improve when participants were presented with photographs compared to line drawings (Snow et al., 2014), although real-world images were noted to have a negative effect on visual search tasks (Bendall et al., 2019), which could impact Stroop performance. The conflicting findings and limited research suggest more thorough investigation in this area is needed.

Rationale Aims and Hypotheses

Fire interest is an important component of YMF. Existing measures of fire interest rely on self-report and or parent responses, which could be failing to identify many youth with heightened fire interest, impacting prevention and early intervention efforts. There is a need to develop an implicit measure of fire interest that can be used directly with youth to identify conspicuous fire interest. Gallagher-Duffy et al. (2009) and Hoerold and Tranah (2014) both investigated the possibility of utilising a modified Stroop task as a measure of implicit fire interest. The two studies used disparate stimuli and produced conflicting results. Further research to elucidate whether a modified pictorial and lexical Stroop task can be used to measure implicit fire interest in youth is warranted.

The current study aimed to assess and compare the construct validity of two implicit fire interest Stroop tasks, a lexical and pictorial version, in three ways: (1) by measuring convergent validity between the implicit fire interest measures and an explicit measure fire interest; (2) investigating whether implicit fire interest measures could distinguish between firesetters and non-firesetters; lastly, (3) assessing predictive validity of implicit fire interest measures in predicting firesetting behaviour. It was hypothesised that implicit and explicit fire measures would display convergent validity by demonstrating significant correlations with each other. It was further hypothesised that self-identified firesetters would report significantly higher levels of fire interest and would show increased attentional bias towards fire stimuli on the implicit measures, compared to self-reported non-firesetters. Lastly, it was hypothesised that explicit and implicit measures would significantly predict real-world firesetting behaviour, but implicit measures would be stronger predictors.

Method

Participants

A total of 86 child participants (and one of their parents/guardians) were recruited for this study using convenience and snowball sampling methods by way of advertisements posted on social media (e.g., Facebook) and local community news boards. Inclusion criteria for the current study required individuals to be aged between 10 and 17 years, with the consent of a parent or guardian. The sample comprised of 48 male, 36 female, and two non-binary children aged between 10 and 17 years ($M = 13.65$, $SD = 1.81$). Participants were allocated into three firesetter classifications: minor firesetter ($n = 24$), serious firesetter ($n = 28$), and non-firesetter ($n = 34$). Finally, 10 parents reported that their child had been diagnosed with ADHD or conduct disorder, six were classified as serious firesetters, two as minor firesetters, and two were non-firesetters. An a priori G-power analysis, with alpha set at 0.05 and statistical power set at 0.8, recommended a sample of 159 participants if anticipating a medium effect size, and 66 participants if anticipating a large effect size, to distinguish between the three groups on the study variables.

Materials

Demographics and Fire History Screen. A brief demographic questionnaire was administered to child participants and their parent. The parental version contained three items including two binary questions adapted from the Fire History Screen (see explanation below; Kolko and Kazdin, 1988), and one question ascertaining whether their child had been diagnosed with ADHD or conduct disorder. The child version of the questionnaire contained four items including age, gender, and the same two binary questions from the Fire History Screen. The binary Fire History Screen items (Yes/No) determined whether participants had previously engaged in minor fire play (i.e., Have you/has your child ever just played with matches, lighters, or the stove, without burning anything else?), and/or serious firesetting behaviour (i.e., Have you/has your child ever burned something like paper, clothes, furniture walls or the house, or set something on fire, without permission from an adult?). Child participant responses were used to classify them as either a serious firesetter (answered yes to the serious firesetting behaviour), minor firesetter (answered yes to only minor fire play), or non-firesetter (answered no to both items).

Fire Setting Scale (FSS). An abbreviated FSS was used in the current study to assess fire interest. The original scale consists of 20-items evenly divided into two subscales measuring antisocial behaviour, and fire interest (Gannon &

Barrowcliffe, 2012). In the current study only the 10 fire interest items were analysed. Participants responded to each item using a 7-point Likert scale (1 "*Not at all like me*" – 7 "*Very strongly like me*"). The responses for each item from the respective subscales were totalled, with possible scores ranging between 10 and 70, and higher scores indicating a higher level of general fire interest. The FSS has demonstrated sound psychometric properties, with firesetters scoring significantly higher than a sample of non-firesetters, establishing discriminate validity (Gannon & Barrowcliffe, 2012). Furthermore, over a two-week period the fire interest subscale has shown excellent test-retest reliability ($r = .83$; Gannon and Barrowcliffe, 2012). Lastly, the fire interest subscale demonstrated excellent internal consistency (Cronbach's $\alpha = 0.93$) in the current study.

Implicit Fire-Stroop Tasks. Two computerised Stroop tasks were used in the current study - a modified Lexical Stroop taken from Hoerold and Tranah (2014), and a Pictorial Stroop inspired by Gallagher-Duffy (2009), using photographs of fire instead of line drawings. For both tasks, stimuli coloured in one of four colour options (described below) were presented successively at the centre of the screen and participants were instructed to identify the colour of the stimuli as quickly and accurately as possible using fixed keyboard responses ("d" = red, "f" = green, "j" = blue, and "k" = yellow). Both tasks began with a practice trial comprised of 28 coloured rectangles presented to participants. The experimental trial for the Lexical Fire-Stroop consisted of 126 coloured words, including 21 neutral words (e.g., sleep, knots, narrow) and 21 fire-related words (e.g., ash, blast, coal) presented three times each in psudeo-randomised order. Conversely, the experimental trial for the pictorial Stroop replaced the coloured words with 128 images, including eight neutral photos of clothing and eight fire-related photos presented eight times each in a pseudo-randomised order. In the pictorial Stroop, participants were required to identify the colour of a rectangle stimulus which appeared at the centre of each image. See Fig. 1 for an example of the practice and experimental trial from both the Lexical and Pictorial Fire-Stroop tasks. Completion time and number of errors were recorded for each trial. If an incorrect response was made, a red "X" would be presented for 400ms in the centre of the screen.

Two measures of implicit fire interest were calculated for each Stroop task. Firstly, Stroop accuracy was obtained from the percentage of correct trials during the presentation of fire-related stimuli. Secondly, Stroop interference was calculated from average reaction time on correct fire-related stimuli trials minus average reaction time on correct neutral stimuli trials. This was represented in the Lexical Stroop using the difference between the average correct response reaction time on fire-related words compared to neutral words. For the pictorial Stroop, the difference between the average correct reaction time on fire-related photos compared to neutral (clothing) photos provided a measure of implicit fire interest. Reduced accuracy and a larger difference for both tasks indicated greater interference from fire stimuli, potentially indicating greater implicit fire interest.

Procedure

This study received approval from the Victoria University Human Research Ethics Committee. Advertisements were circulated across social media and local community news boards. Individuals registered their interest to participate in the current study by accessing a Qualtrics link or QR code through the advertisements. Both children/adolescents and adults were able to register by providing a contact email address, but children were required to provide the contact email of an adult parent or guardian. Afterwards, researchers sent an Information to Participants Involved in Research form detailing the study's aims and procedure, and asked participants to detail their preferred availability to partake in the study should they wish. A zoom link for a scheduled 50-minute meeting was subsequently sent via email.

During the Zoom meeting participants were instructed to set-up in a quiet location, and both the child and their parent or guardian were asked to attend. Firstly, the parent or guardian reaffirmed consent to participate in the current study and completed the demographic questionnaire without the child present. Subsequently, the child accessed the Zoom meeting, reaffirmed their consent to participate in the current study, and completed the FSS followed by the Lexical and Pictorial Fire-Stroop tasks. All tasks were accessed via the program Inquisit (Version 6; Millisecond ®), and links to each task were provided through the chat function over Zoom. To ensure children understood the instructions for the implicit Stroop tasks, they were asked to share their screen allowing researchers to read all instructions to participants and observe their responses. All child participants received a $20 electronic gift voucher for their participation. Data was downloaded, cleaned, and analysed using IBM® SPSS® Statistics Version 27.

Statistical Design

Data screening was conducted to check for accuracy of data entry and assumptions. A single participant failed to complete the lexical and pictorial Fire-Stroop. Continuous variables were screened for normality and outliers. Four outliers were detected with a z-score beyond −3.3 and 3.3, including a single score from the pictorial Fire-Stroop interference, two scores from lexical Fire-Stroop accuracy, and a single score from pictorial Fire-Stroop accuracy. These

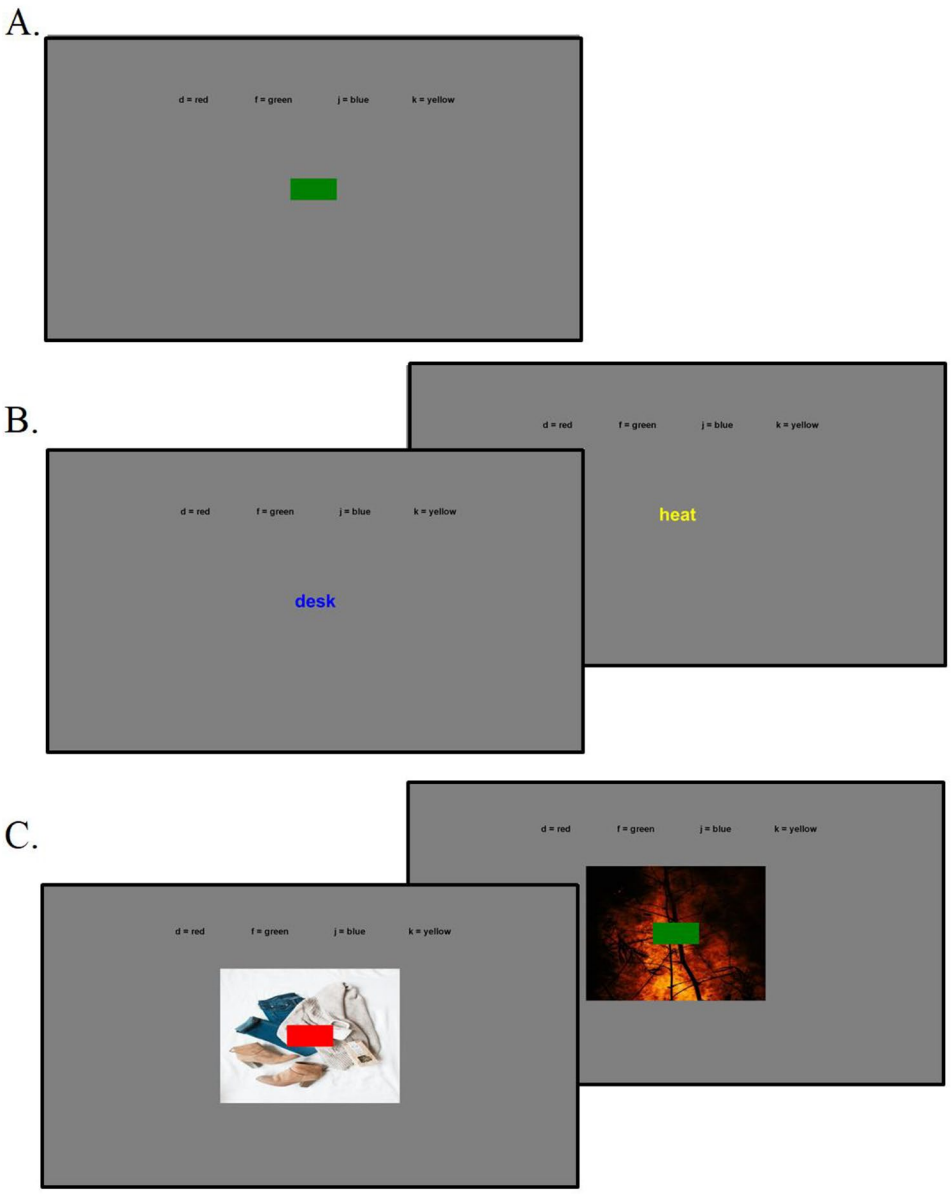

Fig. 1 Screenshots of the Computerised Lexical and Pictorial Fire-Stroop used in the Current Study

outliers were excluded from analyses involving the pictorial and lexical Stroop. After removing outliers, all participants' accuracy on both Stroop tasks were checked and fell above 80%. This process reduced concerns of potential participant ineligibility (e.g., colour-blindness) and task disengagement. No ineligible participants were detected. When outliers were removed, all variables, excluding pictorial and lexical Fire-Stroop accuracy, were normally distributed as the ratio between the skewness and kurtosis statistics were between −3 and 3 (Field, 2018). The accuracy distributions from both Stroops were square-root transformed and then displayed a normal distribution.

Preliminary analyses included two chi-square goodness of fit tests to identify if the children's self-reported firesetting behaviour significantly differed from parental reports, and a chi-square test of independence to determine whether there were gender differences in reported firesetting behaviour. The goodness of fit tests were conducted to determine whether the child's or parental report of firesetting behaviour would be used as the dependent variable in the primary analysis. Firesetting behaviour is considered a socially undesirable action, thus despite children having more intimate knowledge of their own actions, it is possible that children would be less forthcoming in reporting firesetting behaviour. However, if children self-reported higher rates of firesetting behaviour compared to parental reports, the child's self-reported values would be used as the dependent variable. Subsequently, the chi-square test of independence was used to determine if there were significant gender

Table 1 Child- and Parent-report of Minor and Serious Firesetting Behaviour (N = 86)

		Child-reported	Parent-reported
Minor Firesetting	No	36	56
	Yes	50	30
Serious Firesetting	No	58	82
	Yes	28	4

differences in firesetting behaviour that would need to be controlled for in the primary analyses.

The primary analysis initially comprised of Pearson's correlations to explore the convergent validity between the FSS, and the implicit Fire-Stroop tasks. Subsequently, two one-way independent samples ANOVAs were performed to test for differences between non-firesetters, minor firesetters, and serious firesetters in age and fire interest, whereas four one-way independent ANCOVAs were conducted to test for differences between firesetter categories in Lexical Fire-Stroop, and Pictorial Fire-Stroop performance while controlling for the effect of age. Repeatedly, age related improvements have been found in Stroop performance within 12–17 year old participants (Leon-Carrion et al., 2004), thus the effect of age needed to be controlled for when exploring differences between firesetter categories. The assumption of homogeneity of variance was checked for each analysis, and the assumptions of independence of covariate and homogeneity of regression slopes was checked for the two ANCOVAs. Despite running multiple analyses, a Bonferroni adjustment was not applied as the correction reduces statistical power, and thus increases the likelihood of type two errors (Perneger, 1998). However, to compensate for a potential type one error, Scheffe's post hoc analysis was conducted as it is regarded as conservative (Field, 2018).

Lastly, a hierarchical logistic regression was conducted to test if scores on explicit and implicit measures of fire interest could predict firesetting behaviour. To accommodate the need for a binary outcome variable the minor and serious firesetting sample were merged into a single firesetting sample. Step one of the logistical regression model included the necessary covariates (determined by preliminary analyses), the final step of the model added the fire interest subscale and the implicit Lexical and Pictorial Fire-Stroop interference and accuracy scores in order to determine whether explicit or implicit measures were superior predictors of firesetting behaviour. The assumptions checked included: (1) no multivariate outliers; (2) no multicollinearity; and (3) linearity of independent variables and log odds (Field, 2018).

Table 2 Observed and Expected Frequencies of Males and Females across Firesetter Categories (N = 84)

		Non-firesetter	Minor Firesetter	Serious Firesetter
Gender	Males	22(18.9)	10(13.7)	16(15.4)
	Female	11(14.1)	14(10.3)	11(11.6)

Notes. Expected frequencies are presented within parentheses

Results

Preliminary Analysis

Two chi-square goodness of fit tests were used to investigate differences between parental and child reports of serious and minor firesetting. Table 1 presents the observed and expected frequencies for minor and serious firesetting behaviour. Observed frequencies were based on the children's self-reports, whereas the expected frequencies were calculated based on parental reports which suggested 34.9% children reported to be minor firesetters and 4.7% to be serious firesetters. The results of the chi-square goodness of fit tests demonstrated significant differences between child- and parent-reported frequencies for minor firesetting, $\chi^2(1, n = 86) = 20.443$, $p < .001$, and serious firesetting behaviour $\chi^2(1, n = 86) = 149.009$, $p < .001$. Children self-reported minor and serious firesetting behaviour at a significantly greater rate than parental reports of their firesetting behaviour. Given, the considerable discrepancy between child and parental reports, with parents consistently under reporting minor and serious firessetting behaviour compared to adolescents only child-reported firesetting behaviour was used in further analyses.

A chi-square test of independence was conducted to determine if there was a significant gender difference in firesetter categorisation. Two participants who identified as non-binary were excluded from this analysis. The observed and expected frequencies are presented in Table 2, and the results of the chi-square analysis showed no significant difference $\chi^2(2, n = 84) = 3.619$, $p = .164$, demonstrating males and females were proportionally distributed across the firesetter categories. Gender was therefore not controlled for in subsequent analyses.

Primary Analyses

Pearson's correlation analyses were conducted to test the relationships between age, fire interest, and both implicit Stroop tasks. Table 3 presents the descriptive statistics for each variable and the Pearson's correlation matrix. Results revealed only one statistically significant, positive, strong relationship between lexical Fire-Stroop accuracy and pictorial Fire-Stroop accuracy.

Table 3 Descriptive Statistics and Correlations for Age, Fire Interest, and Implicit Stroop Tasks (N = 86)

Variable	*M*(*SD*)	1.	2.	3.	4.	5.	6.
1. Age	13.65(1.83)	-	0.149	0.122	0.124	0.028	−0.016
2. Fire Interest	27.92(12.30)		-	−0.141	0.053	−0.046	0.121
3. Lexical Fire-Stroop Accuracy[cd]	0.97(0.017)			-	0.524**	0.124	−0.124
4. Pictorial Fire-Stroop Accuracy[bd]	0.97(0.022)				-	0.028	−0.081
5. Lexical Fire-Stroop Interference[a]	4.60(116.08)					-	−0.198
6. Pictorial Fire-Stroop Interference[b]	-14.55(102.97)						-

Notes. *M* = Mean; *SD* = Standard Deviation; [a]*N* = 85, [b]*N* = 84, and [c]*N* = 83 due to missing data and outlier; [d] variable has been square-root transformed

** correlation significant at $p < .01$

Table 4 Mean Age, Fire Interest, and Implicit Fire-Stroop Task scores for the different firesetter groups

Variable	Non-firesetters		Minor Firesetters		Serious Firesetters	
	n	*M*(*SD*)	*n*	*M*(*SD*)	*n*	*M*(*SD*)
Age	34	13(1.54)	24	13.58(1.93)	28	14.5(1.73)
Fire Interest	34	21.24(9.07)	24	30.25(12.77)	28	34.0.6(12.14)
Lexical Fire-Stroop Accuracy	32	0.974(0.019)	24	0.975(0.014)	27	0.970(0.016)
Pictorial Fire-Stroop Accuracy	33	0.975(0.024)	24	0.973(0.020)	27	0.972(0.021)
Lexical Fire-Stroop Interference	33	-26.85(113.61)	24	1.57(110.26)	28	44.25(115.83)
Pictorial Fire-Stroop Interference	32	-24.38(119.46)	24	6.58(84.96)	28	-21.42(97.48)

Notes. *M* = Mean; *SD* = Standard Deviation

With alpha set at 0.05, two one-way independent samples ANOVAs and four ANCOVAs were conducted to test for differences in age, self-report fire interest, Lexical Fire-Stoop, and Pictorial Fire-Stroop between the three firesetter classifications (i.e., non-firesetters, minor firesetters, and serious firesetters). Table 4 presents the descriptive statistics for each dependent variable and covariable across the three groups of firesetters.

A significant difference was found in the ages of firesetter groups, $F(2,83) = 5.88$, $p = .004$, $\eta^2 = 0.124$. Scheffe's post hoc analyses revealed that non-firesetters were significantly younger than serious firesetters ($p = .004$), with the remaining comparisons showing a non-significant result.

Scores on the fire interest subscale of the FSS were found to significantly differ between groups $F(2,83) = 11.014$, $p < .001$, $\eta^2 = 0.210$. Scheffe's post hoc analyses showed minor firesetters ($p = .012$), and serious firesetters ($p < .001$), self-reported significantly higher fire interest compared to non-firesetters, and no significant difference was observed between minor and serious firesetters.

Finally, with regards to the implicit Stroop tasks, four ANCOVAs were conducted to investigate differences in interference and accuracy scores between firesetter classifications while controlling for age. Scatterplots depicting the relationship between participants' age and interference scores illustrated homogenous relationship trajectories for each firesetter classification. Thus, with the assumptions met, the results of the four ANCOVAs showed a significant difference on Lexical Fire-Stroop interference score between the firesetter classifications $F(2,81) = 3.143$, $p = .048$, $\eta^2 = 0.072$, and a non-significant differences on Lexical Fire-Stroop accuracy $F(2,79) = 1.143$, $p = .337$, Pictorial Fire-Stroop interference $F(2,80) = 0.701$, $p = .499$, and Pictorial Fire-Stroop accuracy $F(2,80) = 0.697$, $p = .556$.

For all ANCOVAs, controlling for age had no significant effect on the Lexical Fire-Stroop, or Pictorial Fire-Stroop interference and accuracy scores ($p > .05$). Lastly, planned contrast showed that serious firesetters had a significantly higher interference score on the Lexical Fire-Stroop ($p = .014$) compared with non-firesetters, with the remaining comparisons showing a non-significant result.

A hierarchical logistic regression was then conducted to determine if explicit and implicit measures of fire-risk and fire interest could predict firesetting behaviour. Following the significant difference in age between the firesetters and non-firesetters, age was entered into the model at step one to control for its effects. Step two of the model included explicit measures of fire interest (i.e., fire interest subscales), and implicit measures of fire interest (i.e., Lexical and Pictorial Fire-Stroop interference and accuracy). The outcome variable transformed the firesetter classification into a binary variable comprising of non-firesetters and firesetters (merging minor and serious firesetters). All assumptions of a logistical regression were met, max Mahalanobis distance value was 21.69 below the critical region of 22.46 indicating no multivariate outliers. Collinearity statistics fell within acceptable ranges (tolerance statistic > 0.2 and VIF statistic < 10) suggesting no multicollinearity. Lastly, Box-Tidwell transformation showed linearity of independent variables. The classification table for the hierarchical

Table 5 Hierarchical Regression Classification Table (N = 84)

			Predicted		Percentage Correct
			Non-Firesetter	Firesetter	
Model 1	Observed	Non-Firesetter	13	18	41.9
		Firesetter	15	36	70.6
Model 2	Observed	Non-Firesetter	20	11	64.5
		Firesetter	7	44	86.3

logistical regression is presented in Table 5 and the coefficient results are presented in Table 6.

The hierarchical logistical regression showed a significant model at step 1, $\chi2(1) = 6.720$, $p = .010$, Nagelkerke $R^2 = 0.107$, with age correctly identifying firesetter classification 59.8% of the time overall. For every one-year increase in age, the estimated odds ratio favoured a 41.9% [Exp (B) = 1.419, 95% CI = 1.07, 1.88] increased likelihood of firesetting. Adding the explicit fire interest measures (i.e., fire interest subscale), and the implicit measures of fire interest, maintained model significance, $\chi2(6) = 34.810$, $p < .001$, Nagelkerke $R^2 = 0.471$, and increased the overall prediction rate to 78.0%. Age continued to be a significant predictor. However, the fire interest subscale and Lexical Fire-Stroop interference score emerged as unique significant predictors. With every one point of increase in the fire interest subscale the estimated odds ratio predicted a 12.8% [Exp (B) = 1.128, 95% CI = 1.06, 1.20) increased chance of firesetting behaviour. Similarly, with every one second increase in the Lexical Fire-Stroop interference score, the estimated odds ratio predicted a 0.6% [Exp (B) = 1.006, 95% CI = 1.001, 1.012) increased chance, of firesetting behaviour. Lastly, the Lexical Fire-Stroop accuracy and Pictorial Fire-Stroop accuracy and interference scores were not significant unique predictors of firesetting behaviour. Ultimately, age and both explicit and implicit fire interest as measured by the Lexical Fire-Stroop interference score were significant predictors of firesetting behaviour.

Discussion

This study investigated the validity of implicit attentional bias tasks for measuring fire interest by comparing results with an existing explicit fire interest measure, distinguishing between firesetters and non-firesetters, and predicting firesetting behaviour. The hypothesis that implicit and explicit measures of fire interest would show convergent validity was unsupported, as no relationships were found. The hypothesis that firesetters would self-report significantly higher levels of fire interest and show increased attentional bias towards fire stimuli on the implicit measures than non-firesetters was partially supported, with differences found between groups on the self-report measure and Lexical Fire-Stroop interference score, but not on accuracy or the Pictorial Fire-Stroop accuracy and interference scores. Lastly, the hypothesis that an explicit measure of fire interest and performance on implicit measures of fire interest would be predictors of real-world firesetting behaviour was partially supported, with the self-report measure and Lexical Fire-Stroop interference score predictive of firesetting. However, the hypothesis that implicit measures would be stronger predictors of firesetting behaviour (than self-report measures) was not supported.

The lack of correlation between the self-report survey measure and the Fire-Stroop tasks is inconsistent with the limited prior research in this area, where convergent validity was found. For example, Gallagher-Duffy et al. (2009) found a positive relationship between self-reported firesetting frequency and attentional bias as measured by the Pictorial Fire-Stroop. Interestingly, they also found a negative relationship between self-reported fire interest and Pictorial Fire-Stroop attentional bias. This indicates that those demonstrating high fire interest on the implicit measure had in fact self-reported low fire interest – however more implicit bias towards fire was related to more firesetting behaviour. Conversely, Hoerold and Tranah (2014) found higher self-reported fire interest to be related to lower accuracy on a Lexical Fire-Stroop task using words related to fire. In this case, those who performed poorly on the Lexical Fire-Stroop, indicating increased attentional bias towards fire, self-reported higher fire interest. In sum, the limited existent

Table 6 Coefficient Values for Hierarchical Logistical Regression Predicting Firesetting Behaviour (N = 84)

		B	S.E	Wald	df	p	Exp (B)
Step 1	Age	0.350	0.143	5.970	1	0.015	1.419
Step 2	Age	0.455	0.176	6.654	1	0.010	1.059
	Fire Interest	0.120	0.032	13.97	1	< 0.001	1.128
	Lexical Fire-Stroop Accuracy	10.20	20.00	0.26	1	0.610	26793.712
	Pictorial Fire-Stroop Accuracy	-31.421	18.53	2.88	1	0.090	0.000
	Lexical Fire-Stroop Interference	0.006	0.003	5.78	1	0.016	1.006
	Pictorial Fire- Stroop Interference	0.003	0.003	0.70	1	0.404	1.003

Notes. B = Unstandardised Beta Coefficient; S.E = Standard Error

prior research has found relationships between the self-report measures and the Fire-Stroop tasks which were not seen in this study, however, the pattern of relationships was opposing and inconsistent. The reasons for the disparate results is unclear. Despite the three studies (including this one) using slightly different methods and target populations to assess the construct validity of the Fire-Stroop tasks for detecting fire interest, the underlying principle and structure of the Stroop tasks remained the same. The answer may lie in the differences between the cohorts under study. For example, Gallagher-Duffy et al's (2009) study included a group of referred firesetters, where 93% were inpatients in a treatment facility for convicted firesetters. It is possible that their self-reported fire interest was low (when implicit interest was high) because of concerns this would impact their perceived rehabilitation. In contrast, Hoerold and Tranah (2014) recruited their firesetter group from non-firesetter specific clinical and offender services. Their matched high self-report and implicit fire interest may reflect less concern for firesetter specific consequences compared to the participants in Gallagher-Duffy's study. However, this does not explain why our study did not find any relationships among self-report and implicit measures given a general population community sample was used.

Differences in implicit fire interest were observed between non, minor and serious-firsetters on self-report fire interest and the Lexical Fire-Stroop interference score, which were expected. Specifically, minor and serious firesetters self-reported similar levels of fire interest to each other, but higher fire interest levels than non-firesetters. This finding aligns with research suggesting that fire interest is a key motivator in all firesetting behaviour, irrespective of firesetter type (Pooley & Ferguson, 2017). Additionally, literature suggests that it is mental health variables that distinguish between low and high risk firesetters (Dadswell et al., 2021). In this study, the serious firesetters demonstrated greater attentional bias towards fire-related words on the Lexical Fire-Stroop than the non-firesetters only. This suggests that the implicit Lexical Fire-Stroop can detect fire interest in serious firesetters, but may not be salient enough to detect interest in minor firesetters. Contrary to expectations, there was no difference in performance between firesetters (minor nor serious) and non-firesetters on the Pictorial Fire-Stroop interference score or in the accuracy of their responses for either Stroop task, despite Hoerold and Tranah (2014) reporting a significant relationship between fire interest and accuracy on a lexical Fire-Stroop task.

In a similar vein, our expectations regarding the ability of the explicit and implicit fire interest measures to predict firesetting behaviour were partially supported. In addition to age as the strongest predictor, self-reported fire interest and the Lexical Fire-Stroop interference score were successful in predicting firesetting behaviour. However, the self-report measure was unexpectedly a better predictor than the implicit task. The self-report results are in keeping with research indicating that fire interest is among the strongest predictors of firesetting behaviour (Perks et al., 2019). The predictive ability of the Lexical Fire-Stroop task is consistent with Gallagher-Duffy's (2009) study where interference using the Pictorial Fire-Stroop increased with more self-reported firesetting frequency. Interestingly here though, the Pictorial Fire-Stroop was ineffective at predicting firesetting behaviour altogether and the Lexical Fire-Stroop demonstrated superior results.

One possible reason for age appearing as the strongest predictor of firesetting could be the use of a general community sample who volunteered to take part in the study. Typically, as young children move into adolescence, their independence and access to fire materials increases simultaneously with a decrease in parental supervision (Lionetti et al., 2019). Much of the extant firesetter literature uses clinical or firesetter intervention-referred samples, where often the participants have chaotic family circumstances and poor parental supervision (Perks et al., 2019). A high level of parental involvement, support, supervision for the younger adolescents in this study and less opportunity to play with fire may explain why they were less likely to report a firesetting history than the older adolescents.

Although not the focus of this study, the preliminary data analyses highlighted some important findings. In particular, adolescents self-reported firesetting behaviour at a significantly higher rate than their parents (when asked about their child's behaviour). The discrepancies identified between parent and adolescent responses provide evidence that parents may be less accurate at reporting their children's firesetting behaviour. Specifically, it is assumed that adolescent responses are more accurate due to threat of disclosure and social desirability bias making it unlikely they would fabricate instances of firesetting behaviour. Indeed, the converse is the case, and these factors make it more likely they would have under-reported them (Tourangeau & Yan, 2007). It is also assumed that young people would know more about their own behaviour than their parents would – particularly as firesetting is very often a covert activity (Doley et al., 2011). Interestingly, this finding differs to prior research using known firesetter samples recruited from firesetter intervention programs, where the parent-report measures of young firesetter behaviour were more reliable than the child measures (Dadswell et al., 2021). Known firesetters might be more likely to under-report instances of firesetting behaviour because of their previous involvement with consequences stemming from that behaviour (Dadswell et al., 2021). The findings here further support the proposition that self-report or parent-report measures can both be unreliable

and susceptible to bias and implicit measures are worthy of further empirical investigation.

Another unique finding of this study was that both adolescent boys and girls engaged in firesetting at similar rates. This is interesting, as much of the research into firesetting behaviour in adolescents is conducted on available samples that consist predominantly of males who have been referred as part of a fire program. For example, a recent meta-analysis of 25 samples including 12,294 total participants found that 92.7% were male (Sambrooks et al., 2021). Hence, very little is known about girls who light fires. The limited research that does exist, indicates that firesetting in girls and women is underpinned by emotional turmoil (Nanayakkara et al., 2020). Since most knowledge on correlates and predictors of YMF has been derived primarily from male samples, it is unknown if, and how, these factors relate to girls. This study has highlighted that firesetting behaviour is just as common in girls in the general community as it is in boys, and research should consider the potential flaws of applying prior theory and findings to them in the same way. For example, fire interest might influence firesetting behaviour in boys and girls differently.

Despite the novel findings of the current study there are limitations which need to be considered and potential methodological explanations for findings that did not meet our expectations. Firstly, participant allocation to the various firesetter classifications was entirely dependent on self-reported firesetting behaviour. As previously discussed, firesetting is widely considered as socially undesirable and disclosing such behaviour may be perceived as a threat, and therefore participant responses may have been susceptible to bias. Although our community sample of adolescents appear to have been more forthcoming about YMF behaviour compared to previous studies, some may still have withheld information. Furthermore, the binary questions used to allocate participants to the firesetter categories, while adapted from the Fire History Screen, did not capture the frequency or severity of participants' firesetting behaviour. This could potentially result in considerable discrepancies between participants within our firesetter subsamples (i.e., minor and severe) in relation to the seriousness of the YMF behaviour (e.g., in relation to the number of intentionally lit fires, or the stimuli that were set alight). The resulting dilution of strength in the conceptualisation of firesetting behaviour may have exerted particular impact upon the ability of our implicit measures of fire interest to predict firesetting behaviour. It could be argued that the explicit measures were not affected in the same way since parental report likely brings to light more serious YMF behaviour that has been discovered, and because self-report of fire interest is likely to match self-disclosed firesetting incidents. In essence, the overt nature of the reporting in both the explicit independent and dependent variables was matched, unlike for the implicit measures where we were seeking to investigate covert interest. Therefore, future studies would benefit from recruiting a known firesetter sample to investigate whether the implicit measures can accurately distinguish between firesetters and non-firesetters without relying on self-reported behaviour.

While null findings are not a limitation, the Pictorial Fire-Stroop was unable to discriminate between firesetters and non-firesetters, or predict firesetting behaviour. A possibility for these null results may lie with the design of the Pictorial Fire-Stroop. Compared to the previous version of the Pictorial Fire-Stroop (Gallagher-Duffy et al., 2009), this study utilised real photos of fire rather than line drawings. However, the coloured rectangles presented over the photos may have diminished any attentional bias towards the fire photos from the firesetter sample because they were artificially creating a focal point, interfering with engagement with the fire images. In future studies, incorporating an onset delay for the coloured rectangles to ensure participants engage with the fire photos may yield improved results for the Pictorial Fire-Stroop to distinguish between non-firesetters and firesetters.

Further limitations are noted for the Lexical Fire-Stroop. The Lexical Fire-Stroop utilised a list of 21 fire-related and 21 neutral words (Hoerold & Tranah, 2014), with each word having varying association with the category "fire" impacting participants' reaction time. Conducting a preliminary study to ensure participants correctly perceive a list of words belong to the desired category could prove vital in enhancing word-related implicit tests. Lastly, data collection was conducted over Zoom during a global pandemic while Australian citizens were under varying stages of lockdown. Therefore, researchers were unable to standardise the testing apparatus used by participants when they were completing the implicit Stroop tasks. Whilst administering the Stroop tasks via Inquisit proportions of all stimuli were standardised in an attempt to control for differing screen sizes, and participants were instructed to share screen to allow the researchers to monitor responses and ensure participants understood instructions. Nonetheless, complete standardisation was not possible. It is unknown what impact variations in screen brightness and size may have had on task performance. Ideally, future studies should administer these tasks in a more standardised environment. Whilst the current study recruited a similar sized sample to Gallagher-Duffy et al. (2009) and Hoerold and Tranah (2014), $n = 98$ and $n = 64$, respectively, and all three studies found small to moderate effect sizes in their analyses, some small effects may not have been observable (e.g. results related to Pictorial Fire-Stroop). To truly elucidate the efficacy of the implicit Stroop tasks a larger sample may be required despite the practical difficulties in recruiting large adolescent firesetter samples.

The current study contributes to a novel, but evolving area of literature investigating implicit measures of fire interest. This area of research is in a state of infancy requiring further work to improve implicit fire interest measures to circumvent the limitations of explicit measures. One possible avenue for future research is to investigate the effectiveness of alternative implicit fire interest paradigms. Within the field of cognitive psychology, the Implicit Association Task (IAT) has been widely used as a measure of unconscious associations between attributes and categories. It has been successfully used to assess implicit racist associations, food preferences, and sexual preferences (Geer & Robertson, 2005; Greenwald et al., 2009; Maison et al., 2004). Within the YMF literature, the Stroop paradigm is the only measure used thus far to investigate implicit fire interest, however a modified IAT task could be developed as an alternative way to measure attentional bias towards fire, and accurately predict firesetting behaviour. Furthermore, this study investigated a community sample, but future research should be expanded to contrast performance on the implicit and explicit measures between a community sample of non-firesetters and a sample of known juvenile firesetters.

Firesetting behaviour is an ever-increasing problem exacerbated by the changing climate. The current study demonstrated the high rates of YMF within a conveniently recruited community sample, highlighting the considerable community risk YMF poses. Similarly, the current study challenges the stereotypical profiles established within the literature, as no gender differences were observed in firesetting behaviour. In addition, existing profiles of firesetters are primarily based around studies recruiting known juvenile firesetters. However, what this fails to address is the covert nature of firesetting behaviour, which makes it difficult to study, and known juvenile firesetters only make up a sub portion of the firesetter population. The assessment of fire interest needs to improve beyond the existing self-report and parental report measures which are successful in the broad sense but are also inherently problematic. Whilst the findings of the current study did not establish the efficacy of a Lexical or Pictorial Fire-Stroop as superior measures of fire interest in their current form, it is clear that more work can be done to improve these tasks, or to develop alternative implicit measures of fire interest. Development of effective implicit fire interest measures is urgently needed to improve the assessment and detection of those most at risk of firesetting behaviour to enable early intervention or proactive prevention strategies to be effectively implemented. The ultimate goal of this work is to minimise the potential of dangerous YMF occurring, and the serious financial, health and social consequences that arise from it.

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