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The association between the Big Five personality traits and driving behaviors: A systematic review and meta-analysis

Xiaohui Luo [a,b], Yan Ge [a,c], Weina Qu [a,c,*]

[a] CAS Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China
[b] Faculty of Psychology, Beijing Normal University, Beijing, China
[c] Department of Psychology, University of Chinese Academy of Sciences, Beijing, China

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ABSTRACT

Although a large number of studies have examined the relationship between the Big Five personality traits and driving behaviors, consistent evidence for their relationships is still lacking. The main purpose of this study was to systematically review the relationships between the Big Five personality traits and various driving behaviors with different intentions (including risky, aggressive, and positive driving behaviors) through a meta-analysis. A total of 34 articles met the inclusion criteria for the meta-analysis. The results showed that risky and aggressive driving behaviors were negatively associated with conscientiousness ($r = –0.21$; $r = –0.26$), agreeableness ($r = –0.23$; $r = –0.37$), and openness ($r = –0.08$; $r = –0.07$), positively associated with neuroticism ($r = 0.11$; $r = 0.26$), and nonsignificantly associated with extraversion ($r = 0.06$; $r = –0.06$). Positive driving behaviors were positively associated with conscientiousness ($r = 0.30$), agreeableness ($r = 0.32$) and openness ($r = 0.20$) but nonsignificantly associated with extraversion ($r = 0.08$) and neuroticism ($r = –0.10$). In addition, the association between the Big Five personality traits and driving behaviors could be moderated by age, gender and type of personality measure. In conclusion, this study contributes to the literature by quantitatively synthesizing existing findings and reconciling previous debates on the relationship between the Big Five personality traits and driving behaviors. From a practical perspective, our findings provide valuable insights into driver selection and screening, policy development, and safety intervention design.

1. Introduction

Road traffic accidents have long been a public safety problem worldwide. It is estimated that approximately 1.3 million people die in road traffic accidents each year (World Health Organization, 2022). Researchers have pointed out that human factors, especially the driving behaviors of drivers, are key factors in road traffic accidents (Lewin, 1982; Rowe et al., 2015), which account for >90 % of road accidents (Rothengatter, 1991; Rumar, 1986). Therefore, a large number of studies have focused on various types of risky driving behaviors, such as speeding (Pantangi et al., 2020; Sârbescu and Rusu, 2021) and tailgating (Kovaceva et al., 2020; Xu et al., 2021).

However, there is a broader classification of driving behaviors in terms of the intentions behind them. Unsafe driving behavior, including risky and aggressive driving, with negative intentions and positive driving behavior with positive intentions are considered the two important aspects of driving behavior that constitute the two major categories of driving behavior in our daily lives (Özkan and Lajunen, 2005; Shen et al., 2018). To reduce the number of traffic accidents and improve the traffic safety environment, researchers have explored the predictors of various types of driving behaviors, among which drivers' personalities have been found to be critical predictors of driving behaviors (Sârbescu and Rusu, 2021; Zhang et al., 2019; Zhang and Chan, 2016). Specifically, previous studies have confirmed significant associations between driving behavior and many personality traits, such as sensation seeking (Lemarié et al., 2019; Qu et al., 2020; Riendeau et al., 2018) and anger (Ge et al., 2017; Herrero-Fernández, 2016; Montoro et al., 2018). More importantly, the Big Five personality traits have also been found to be closely related to driving behaviors (Ge et al., 2020; Qu et al., 2015; Shen et al., 2018; Wang et al., 2018; Xu et al., 2018; Zhang et al., 2018).

In the present study, we systematically examined previous research on the relationships between the Big Five personality traits and driving behaviors with different intentions. We then used meta-analysis to

* Corresponding author at: CAS Key Laboratory of Behavioral Science, Institute of Psychology, 16 Lincui Road, Chaoyang District, Beijing 100101, China.
E-mail address: quwn@psych.ac.cn (W. Qu).

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quantitatively explore the associations between the Big Five personality traits and various driving behaviors, as well as their moderators. Finally, we discussed our results, as well as their theoretical and practical value, based on the findings of the meta-analysis and previous studies.

1.1. Driving behaviors with different intentions

Despite the volume of relevant research, a widely accepted classification of driving behavior is still lacking. Considering that intention was one of the main predictors of human behavior (Fishbein and Ajzen, 1977), Özkan and Lajunen (2005) pointed out that researchers should not only focus on what drivers did in traffic but also think about what drivers intended to do in traffic. They emphasized the importance of interpreting driving behavior according to drivers' intentions (positive or negative). According to this view, driving behaviors can be divided into two main categories based on their intentions: risky driving behaviors and aggressive driving behaviors with negative intentions and positive driving behaviors with positive intentions.

With negative intentions, risky and aggressive driving are "deliberate behaviors that may endanger the safety of both the driver and other road users" (Zhang and Chan, 2016). However, the negative intentions behind these two types of driving behaviors are slightly different. Aggressive driving behavior is "intended to injure or harm other road users physically or psychologically" (Lajunen et al., 1998). Typical aggressive driving behaviors include flashing lights at another driver, yelling at another driver, cutting off other vehicles, and even ramming other vehicles (Deffenbacher et al., 2002; Özkan et al., 2010), which can be measured by the aggressive violation subscale of the Driver Behavior Questionnaire (DBQ; Özkan and Lajunen, 2005), the aggressive driving subscale of the Dula Dangerous Driving Index (DDDI; Dula and Ballard, 2003), and the Driving Anger Expression (DAX) scale (Deffenbacher et al., 2002). In contrast, risky driving behavior, without harmful intention toward others, only involves drivers' selfish motives such as sensation seeking and time urgency (Dula and Ballard, 2003; Richer and Bergeron, 2012). Behaviors such as speeding, tailgating, running red lights, frequent lane changes, not using seat belts and drunk driving are all common risky driving behaviors (Dula and Ballard, 2003), which can be measured by the ordinary violation subscale of the DBQ (Özkan and Lajunen, 2005) and the risky driving subscale of the DDDI (Dula and Ballard, 2003).

With positive intentions, positive driving behaviors are intended "to take care of the traffic environment or other road users, to help and to be polite with or without safety concerns" (Özkan and Lajunen, 2005). As opposed to aggressive and risky driving behaviors, traffic rules, regulations and safety issues are not the primary considerations of positive driving behaviors; instead, positive driving behaviors are more concerned with the traffic environment and other drivers to promote smooth driving and improve the traffic environment (Han and Zhao, 2020; Özkan and Lajunen, 2005). For example, avoiding following closely so as not to disturb the driver in front and adjusting speed for other drivers trying to overtake can be considered positive driving behaviors (Özkan and Lajunen, 2005) because they are not required by traffic laws but motivated by the positive intent of a driver (Han and Zhao, 2020). To measure positive driving behaviors, the Positive Driver Behavior Scale (PDBS; Özkan and Lajunen, 2005) was developed as a new addition to the DBQ, which originally focused only on dangerous driving behavior. Moreover, other self-reported measures, such as the Prosocial Driving Scale (Harris et al., 2014), are also proper measures for driving behaviors with positive intentions.

1.2. Relationships between the Big Five personality traits and driving behaviors

The Big Five personality traits constitute a widely accepted personality construct that consists of five dimensions: conscientiousness, agreeableness, extraversion, openness, and neuroticism (McCrae and Costa, 1987; McCrae and Costa, 2003). A large body of research has explored the relationship between the Big Five personality traits and various driving behaviors; however, the findings have been inconsistent.

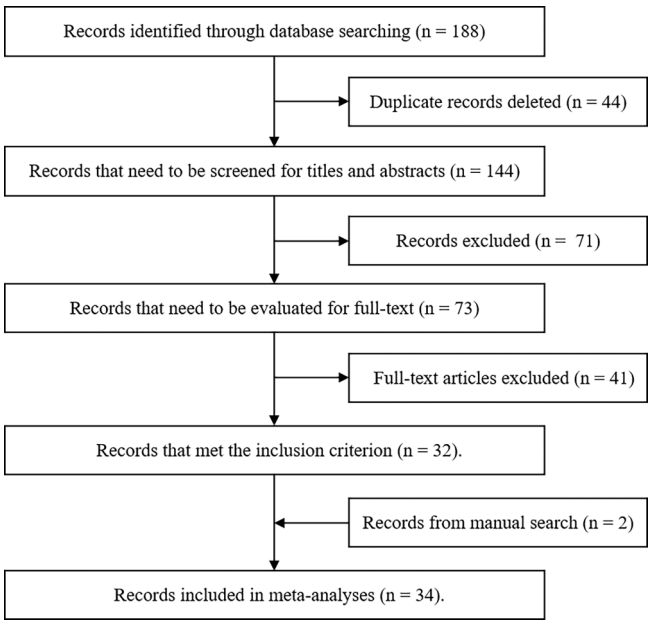

Fig. 1. The literature search and study selection process.

1.2.1. Relationships between the Big Five personality traits and risky and aggressive driving behaviors

Most studies on the associations between conscientiousness, agreeableness, neuroticism and risky and aggressive driving behaviors were relatively consistent in their findings. Conscientiousness and agreeableness were found to be negatively associated with risky driving behaviors (Ge et al., 2020; Maier et al., 2020; Qu et al., 2015; Wang et al., 2018; Zhang et al., 2018) and aggressive driving behaviors (Shen et al., 2018; Xu et al., 2018; Chraif et al., 2016; Dahlen et al., 2012; Taubman-Ben-Ari and Yehiel, 2012), whereas neuroticism was found to be positively associated with risky (Dahlen and White, 2006; Luria, 2018; Qu et al., 2015; Zhang et al., 2018) and aggressive driving behaviors (Burtăverde et al., 2016; Ge et al., 2020; Jovanović et al., 2011; Zhang et al., 2017). However, there are still some studies that have shown conflicting results. Regarding conscientiousness, some researchers found a positive relationship with risky driving behaviors (de Vries et al., 2017; Parr et al., 2016) and aggressive driving behaviors (Javadi et al., 2015), whereas others did not find significant associations between conscientiousness and risky and aggressive driving behaviors (Aghabayk et al., 2020; Devarasetty et al., 2014). Similarly, regarding agreeableness, some studies have shown a positive relationship with risky driving behaviors (Javadi et al., 2015), whereas others have shown a nonsignificant association between agreeableness and risky and aggressive driving behaviors (Watling, 2018; Sârbescu and Maricuţoiu, 2019). Regarding neuroticism, some researchers found a negative association with risky driving behaviors (Kalantari et al., 2021; Starkey and Isler, 2016), whereas others found nonsignificant associations between neuroticism and risky and aggressive driving behaviors (Britt and Garrity, 2006; Lustman, 2011).

In addition, regarding extraversion and openness, previous studies failed to reach a consensus about their relationships with risky and aggressive driving behaviors. Some studies have shown that extraversion is positively associated with risky driving behaviors (Baran et al., 2021; Kalantari et al., 2021; Maier et al., 2020; Parr et al., 2016) but negatively associated with aggressive driving behaviors (Shen et al., 2018; Zhang et al., 2017; Zhang et al., 2018). However, other studies did not find a significant association between extraversion and risky driving

Table 1
Descriptive statistics of fifteen pairwise relationships between the Big Five personality traits and driving behaviors.

Pairwise relationship		*n*	*k*	Sample size			*r*				
				Min	Max	Cumulative	Min	Max	Median	Mean	*SD*
Risky driving behavior	Conscientiousness	24	24	40	421	5279	–0.43	0.39	–0.25	–0.19	0.20
	Agreeableness	20	20	40	421	4658	–0.53	0.17	–0.21	–0.22	0.20
	Extraversion	19	19	40	421	4289	–0.27	0.28	0.08	0.06	0.15
	Openness	18	19	40	421	4182	–0.27	0.34	–0.06	–0.07	0.14
	Neuroticism	18	18	40	421	4426	–0.29	0.46	0.08	0.10	0.20
Aggressive driving behavior	Conscientiousness	19	20	91	422	5401	–0.49	0.18	–0.25	–0.25	0.16
	Agreeableness	15	16	91	422	4558	–0.55	–0.11	–0.36	–0.36	0.12
	Extraversion	14	15	91	422	4263	–0.29	0.20	–0.01	–0.05	0.13
	Openness	14	15	91	422	4263	–0.24	0.03	–0.03	–0.07	0.08
	Neuroticism	16	17	91	422	4675	–0.03	0.47	0.28	0.25	0.14
Positive driving behavior	Conscientiousness	9	9	132	1181	3375	0.04	0.50	0.31	0.29	0.13
	Agreeableness	7	7	203	1181	3015	0.25	0.55	0.26	0.31	0.11
	Extraversion	7	7	203	1181	3015	–0.01	0.36	0.03	0.08	0.13
	Openness	7	7	203	1181	3015	0.12	0.35	0.16	0.19	0.08
	Neuroticism	7	7	203	1181	3015	–0.38	0.06	–0.06	–0.09	0.14

Note: n denotes the number of articles included. *k* denotes the number of studies included. *r* denotes the zero-order correlation. *SD* denotes standard deviation.

behaviors (Valero-Mora et al., 2021; Riendeau et al., 2018) or aggressive driving behaviors (Britt and Garrity, 2006; Burtăverde et al., 2016; Chraif et al., 2016). Similarly, although some studies revealed negative associations between openness and risky and aggressive driving behaviors (Luria, 2018; Maier et al., 2020; Shen et al., 2018; Zhang et al., 2018), others did not find significant associations (Ge et al., 2020; Taubman-Ben-Ari and Yehiel, 2012; Wang et al., 2018; Xu et al., 2018). Therefore, the relationships between extraversion and openness and risky and aggressive driving behaviors remain controversial.

1.2.2. Relationships between the Big Five personality traits and positive driving behaviors

Although many studies have examined the relationship between personality traits and driving behaviors, most of them have focused on risky and aggressive driving behaviors, and few have addressed positive driving behaviors (Shen et al., 2018). In the limited number of studies on the relationships between the Big Five personality traits and positive driving behaviors, most found that conscientiousness, agreeableness, and openness were positively associated with positive driving behaviors (Harris et al., 2014; Shen et al., 2018; Taubman-Ben-Ari and Yehiel, 2012; Wang et al., 2018), whereas extraversion and neuroticism were not significantly associated with positive driving behaviors (Ge et al., 2020; Mahembe and Samuel, 2016; Xu et al., 2018). However, the findings have been inconsistent. For example, Devarasetty et al. (2014) did not find significant associations between conscientiousness and positive driving behaviors, and Shen et al. (2018) revealed that drivers with high levels of extraversion or low levels of neuroticism exhibited more positive driving behaviors.

Considering the contradictory findings regarding the relationship between the Big Five personality traits and various driving behaviors, a synthesis of existing research is needed. Akbari et al. (2019) conducted a meta-analysis of the correlations between the Big Five personality traits, sensation seeking, driving anger, and risky driving behaviors. They concluded that risky driving behaviors were significantly associated only with agreeableness and neuroticism and not with conscientiousness, extraversion, or openness, which was somewhat in conflict with our findings based on the qualitative analysis of the literature (Maier et al., 2020; Shen et al., 2018; Zhang et al., 2018). Moreover, in our opinion, this meta-analysis had the following three limitations. First, this meta-analysis did not distinguish between risky driving behaviors without harmful intentions to others and aggressive driving behaviors with the intent to harm others; instead, it considered both types of driving behaviors as risky driving behaviors, which hindered a deeper understanding of the relationship between the Big Five personality traits and these two types of unsafe driving behaviors as well as the differences between these relationships. Second, this meta-analysis did not address positive driving behaviors with positive intentions but rather focused only on driving behaviors with negative intentions. Since positive driving behaviors are a part of everyday life and play an important role in improving the traffic safety environment (Özkan and Lajunen, 2005), the relationship between the Big Five personality traits and positive driving behaviors also warrants our attention. Finally, this meta-analysis used only "risky driving (RD)" or "risky driving behaviors (RDBs)" to search for risky driving behaviors, which may miss other risky driving behaviors, such as those referred to as dangerous driving behaviors or unsafe driving behaviors. Therefore, a more comprehensive analysis of the relationships between the Big Five personality traits and various driving behaviors with different intentions is still needed.

1.3. The present study

The purpose of this study was to quantitatively examine the associations between the Big Five personality traits and risky, aggressive and positive driving behaviors and to identify moderators of these associations using a meta-analytic approach. Previous studies have shown that demographic variables, including age (Rhodes and Pivik, 2011; Wickens et al., 2011; Zhang et al., 2017), gender (Oltedal and Rundmo, 2006; Sârbescu et al., 2014; Zhang et al., 2017) and driving experience (Song et al., 2021; Tao et al., 2017), are significant predictors of driving behaviors. Some studies also found that they could moderate the associations between personality traits and driving behaviors (Bogdan et al., 2016; Brown et al., 2017; Xu et al., 2014). In addition, the types of personality measures could also moderate the relationship between personality traits and driving behaviors (Akbari et al., 2019; Zhang et al., 2019). Therefore, the moderating effects of these four variables (i.e., age, gender, driving experience and types of personality measures) were explored.

2. Method

2.1. Inclusion and exclusion criteria

Studies that satisfied the following criteria were included: (a) studies that included valid operationalizations for at least one dimension of the Big Five personality traits and one kind of risky driving behavior, aggressive driving behavior or positive driving behavior; (b) studies that either tested the bivariate associations between the variables of interest or investigated the differences in the Big Five personality traits between individuals who did or did not perform risky driving behavior, aggressive driving behavior or positive driving behavior; (c) studies that clearly reported the quantitative data required in effect size calculation; and (d) studies written in English. Additionally, we excluded studies that

Table 2
Meta-analysis results of correlations between the Big Five personality traits and driving behaviors.

Relationships		*n*	Random effects model result			Study heterogeneity test			Publication bias			
			k_1	Pooled *r* (95 % CI)	*p*	τ^2 (95 % CI)	I^2 (%) (95 % CI)	*Q* (*df*)	*Z*	k_3	Pooled *r* (95 % CI)	*p*
Risky driving behavior	Conscientiousness	6608	24	–0.21 (–0.28, –0.14)	**<0.001**	0.03 (0.01, 0.08)	84.43 (75.85, 94.19)	115.88 (23)***	3.63***	24	–0.21 (–0.28, 0.14)	**<0.001**
	Agreeableness	5987	20	–0.23 (–0.32, –0.14)	**<0.001**	0.04 (0.02, 0.09)	89.61 (81.32, 95.13)	186.37 (19)***	1.08	20	–0.23 (–0.32, –0.14)	**<0.001**
	Extraversion	7256	19	0.06 (–0.01, 0.13)	0.109	0.20 (0.01, 0.04)	80.20 (63.27, 90.38)	103.90 (18)***	1.27	21	0.04 (–0.03, 0.11)	0.31
	Openness	5511	19	–0.08 (–0.14, –0.03)	**0.003**	0.01 (0.00, 0.03)	63.77 (36.77, 87.24)	50.60 (18)***	1.05	20	–0.09 (–0.15, –0.04)	**0.002**
	Neuroticism	5755	18	0.11 (0.01, 0.21)	**0.028**	0.04 (0.02, 0.09)	90.42 (82.50, 95.72)	184.23 (17)***	–1.69	18	0.11 (0.01, 0.21)	**0.028**
Aggressive driving behavior	Conscientiousness	5401	20	–0.26 (–0.32, –0.18)	**<0.001**	0.03 (0.01, 0.06)	87.19 (77.39, 93.86)	149.50 (19)***	0.98	20	–0.26 (–0.32–0.18)	**<0.001**
	Agreeableness	4666	16	–0.37 (–0.42, –0.32)	**<0.001**	0.01 (0.01, 0.04)	77.37 (58.33, 91.28)	66.43 (15)***	2.86**	16	–0.37 (–0.42, –0.32)	**<0.001**
	Extraversion	4371	15	–0.06 (–0.12, 0.01)	0.076	0.01 (0.00, 0.04)	77.21 (56.87, 91.13)	64.11 (14)***	2.62**	17	–0.08 (–0.14, –0.01)	**0.017**
	Openness	4263	15	–0.07 (–0.12, –0.03)	**0.002**	0.00 (0.00, 0.01)	57.37 (17.94, 79.81)	33.46 (14)**	1.93	18	–0.09 (–0.14, –0.05)	**<0.001**
	Neuroticism	4675	17	0.26 (0.20, 0.32)	**<0.001**	0.02 (0.01, 0.04)	80.26 (63.96, 92.12)	74.87 (16)***	–2.26*	17	0.26 (0.20, 0.32)	**<0.001**
Positive driving behavior	Conscientiousness	3375	9	0.30 (0.21, 0.38)	**<0.001**	0.01 (0.00, 0.07)	83.49 (62.13, 96.25)	36.28 (8)***	–0.83	9	0.30 (0.21, 0.38)	**<0.001**
	Agreeableness	3015	7	0.32 (0.23, 0.41)	**<0.001**	0.02 (0.00, 0.08)	85.53 (64.37, 96.95)	40.18 (6)***	–0.83	9	0.35 (0.27, 0.42)	**<0.001**
	Extraversion	4653	7	0.08 (–0.02, 0.18)	0.107	0.02 (0.00, 0.08)	85.72 (64.58, 97.00)	40.70 (6)***	–0.79	9	0.12 (0.03, 0.20)	**0.001**
	Openness	3015	7	0.20 (0.14, 0.26)	**<0.001**	0.00 (0.00, 0.03)	63.15 (6.27, 92.48)	15.35 (6)*	–0.81	9	0.22 (0.17, 0.28)	**<0.001**
	Neuroticism	3015	7	–0.10 (–0.20, 0.01)	0.075	0.02 (0.01, 0.10)	87.59 (69.42, 97.43)	49.47 (6)***	0.50	9	–0.14 (–0.24, –0.04)	**0.006**

Note: *n* denotes the cumulative sample size; k_1 denotes the number of studies included; *r* denotes the zero-order correlation; CI denotes the confidence interval. *Z* denotes the *Z* statistic of Egger's regression test. Egger's regression tests were not performed for the associations between the Big Five personality traits and positive driving behaviors due to the lack of studies; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

recruited participants driving two-wheeled vehicles.

2.2. Literature search and study selection

A literature search was conducted on the Web of Science, PsycArticles, and PsycINFO databases from inception to March 9th, 2022 by the first author of this study. The Boolean search was as follows: ("Big Five personality" OR conscientiousness OR agreeableness OR extraversion OR openness OR neuroticism) AND ("driving behavior" OR "driving behaviour" OR "aggressive driving" OR "positive driving" OR "risky driving" OR "unsafe driving" OR "dangerous driving" OR "aberrant driving"). The studies were independently screened by two undergraduate students majoring in Psychology. Any disagreements and uncertainties were discussed with the first author of this study until a consensus was reached. We first removed duplicate studies and screened the titles and abstracts of the retained literature. Then, the full texts of the identified studies were further checked to determine their appropriateness for meta-analyses. Finally, we manually examined the reference lists of the included literature and related review articles (Akbari et al., 2019) to include additional articles that might meet our requirements.

2.3. Data extraction

The following information was extracted from each study: (1) study characteristics (i.e., author and publication year); (2) descriptions and measures of the Big Five personality traits and driving behaviors; (3) sample characteristics (i.e., sample size, mean age, percentage of males, average driving experience since the driver's license was obtained, and characteristics of participants); and (4) statistics of associations between the Big Five personality traits and three types of driving behaviors, including risky driving, aggressive driving and positive driving.

These data were independently extracted and coded by two undergraduate students majoring in Psychology. To ensure that both coders had a consistent understanding of the coding scheme, we first had a "trial coding" phase. During this phase, the two coders independently coded nine articles and discussed the differences in coding with all authors of this study to reach consensus on the coding scheme. In addition,

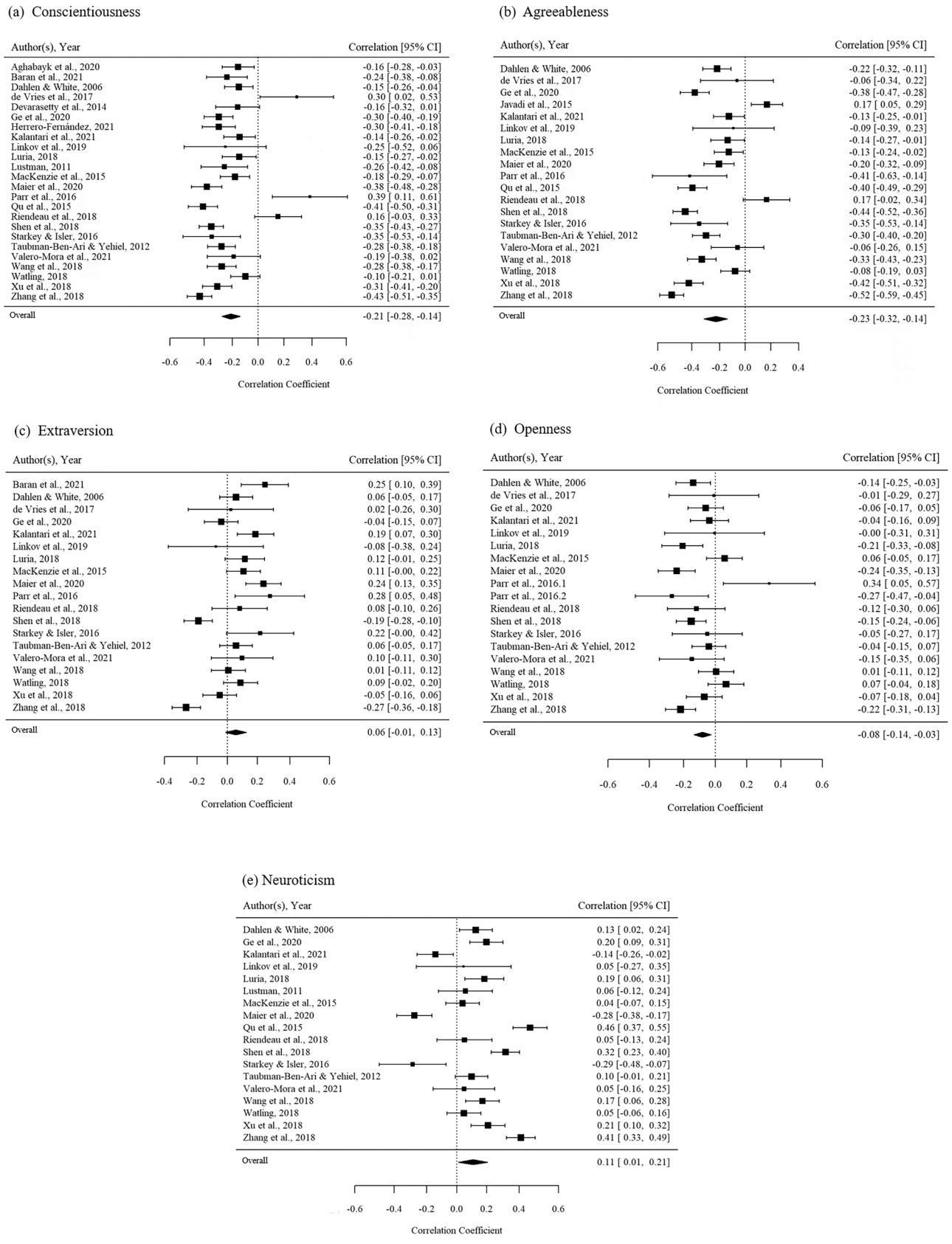

Fig. 2. Standardized effect sizes and forest plots for the sample of studies regarding the Big Five personality traits and risky driving behaviors.

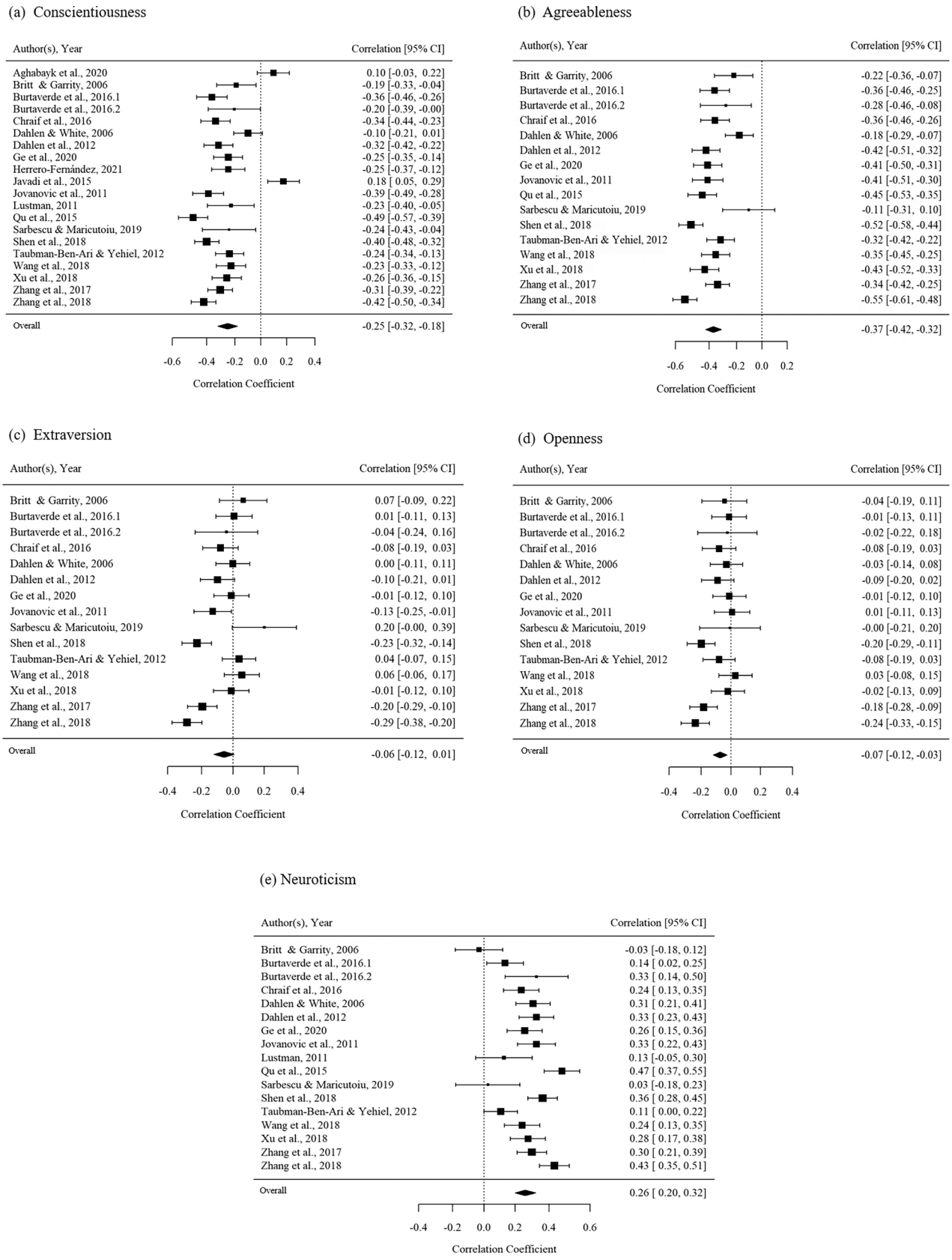

Fig. 3. Standardized effect sizes and forest plots for the sample of studies regarding the Big Five personality traits and aggressive driving behaviors.

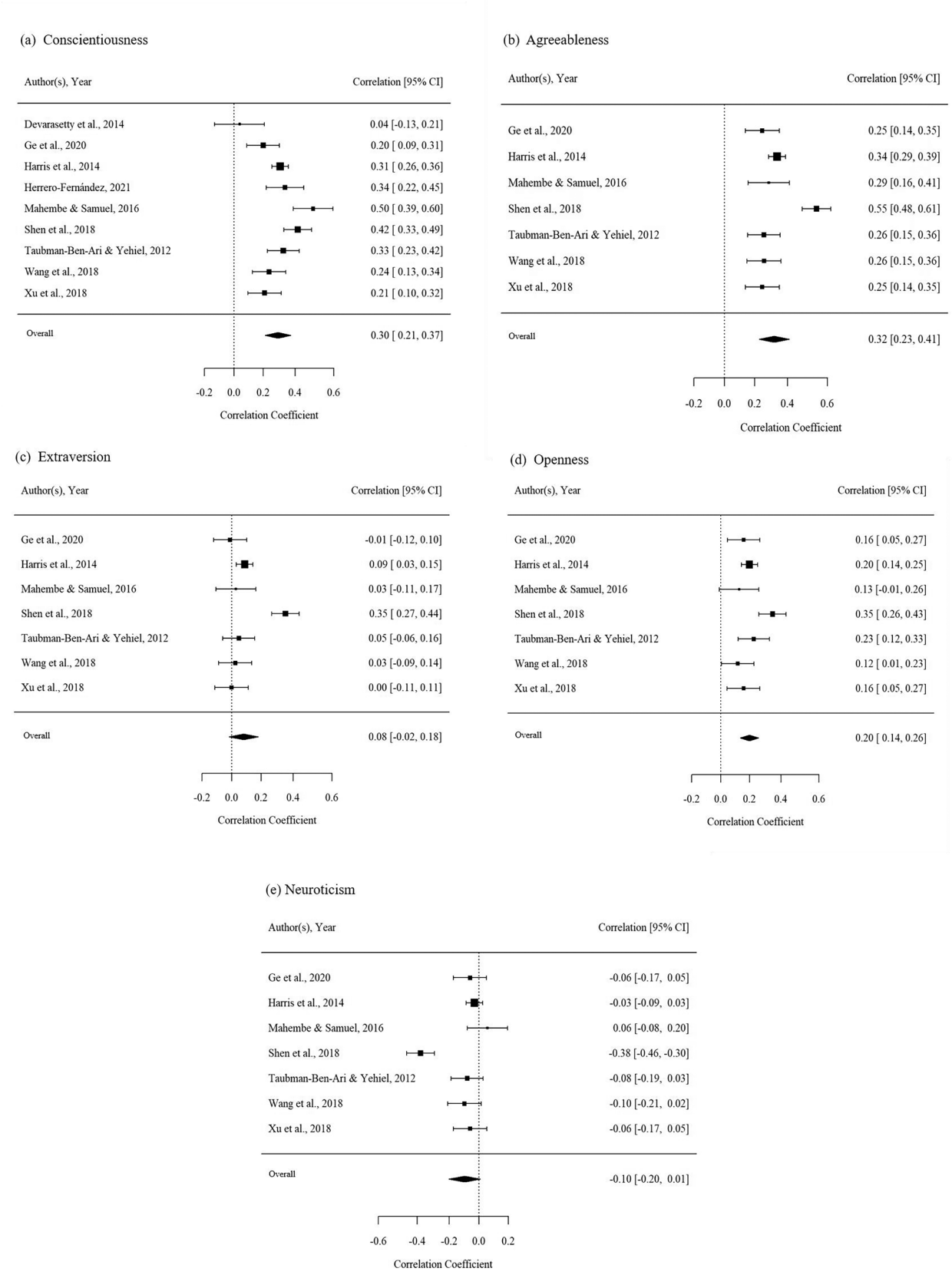

Fig. 4. Standardized effect sizes and forest plots for the sample of studies regarding the Big Five personality traits and positive driving behaviors.

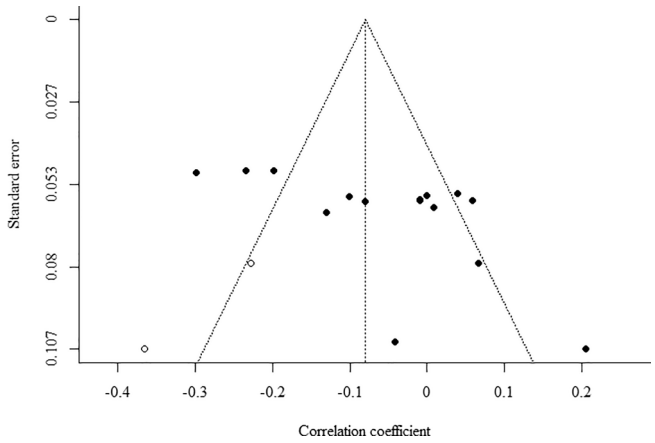

Fig. 5. Publication bias funnel plot for the studies regarding the association between extraversion and aggressive driving behaviors. *Note*. Filled dots denote observed studies and hollow dots denote imputed studies.

some necessary modifications and improvements to the coding table were made based on the problems encountered during this phase. Then, in the formal coding phase, the two coders independently coded all 75 articles. Inconsistencies in the coding results between the two coders were only shown for five of these 75 articles, suggesting a high coding consistency of study characteristics coded by the two coders (i.e., (75–5)/75 = 93.33 %). Finally, inconsistent coding results were re-examined and discussed until a consensus was reached.

Notably, since the independence assumption (i.e., the effect sizes of different studies are independent of each other; in other words, the effect sizes are from independent studies) of meta-analysis would be violated if more than one effect size (i.e., zero-order correlation in this study) from a study was included, the average of the correlations for any study that reported multiple correlations between one dimension of the Big Five personality traits and one type of driving behavior was calculated and used, which was a widely acceptable treatment to satisfy the independence assumption of meta-analysis (Zhang and Chan, 2016; Zhang et al., 2019).

2.4. Data analysis

A meta-analysis of each pair of personality traits and driving behaviors was conducted to examine the association between the Big Five personality traits and three types of driving behaviors (i.e., risky driving, aggressive driving, and positive driving). To assess the correlational relationship between personality traits and driving behaviors, Pearson's correlation coefficient (r) was used as the effect size for each study. Considering the variety in the populations of the included studies (Quintana, 2015), a random effects model was used to estimate the summary effect sizes.

To evaluate study heterogeneity, the I^2 statistic, tau-squared (τ^2), and Q statistic were calculated and reported. The variation between effect sizes included in a meta-analysis could be attributed to two sources, within-study error and real heterogeneity in effect size (Quintana, 2015). The I^2 statistic reflects the proportion of observed variation in effect sizes that could account for the real variation between studies, with 25 %, 50 %, and 75 % indicating low, moderate, and high levels of variance, respectively (Higgins et al., 2003). A related statistic is tau-squared, which represents the total amount of heterogeneity. A smaller tau-squared suggests lower levels of heterogeneity, and a tau-squared that equals zero indicates no heterogeneity between studies. Moreover, the Q statistic based on a null hypothesis significance test represents the extent of the heterogeneity that could be attributed to the real variation between studies, and a statistically significant Q statistic suggests that the null hypothesis of study homogeneity should be rejected. In addition, to better illustrate study heterogeneity, forest plots for fifteen pairs of the Big Five personality traits and driving behaviors were shown to visualize the effect sizes and the confidence intervals (CIs) of the included studies. In the forest plots, the point estimates of each study were represented by squares, with larger squares indicating a larger contribution to the pooled effect size. The pooled effect size of all

Table 3
Test of significance for the meta-regression models regarding presumed moderators.

Moderator		Conscientiousness			Agreeableness			Extraversion			Openness			Neuroticism		
		k	Q_m (df)	p	k	Q_m (df)	p	k	Q_m (df)	p	k	Q_m (df)	p	k	Q_m (df)	p
Risky driving behavior	Mean age	21	5.58 (1)	**0.018**	18	7.34 (1)	**0.007**	17	6.53 (1)	**0.011**	17	0.47 (1)	0.495	16	6.06 (1)	**0.014**
	Percentage of male drivers	23	3.65 (1)	0.056	20	1.90 (1)	0.169	19	1.01 (1)	0.314	19	1.93 (1)	0.164	18	0.39 (1)	0.532
	Driving experience	12	0.21 (1)	0.645	10	0.02 (1)	0.884	9	0.27 (1)	0.604	8	0.00 (1)	0.958	10	0.55 (1)	0.460
	Types of personality measures	24	1.76 (3)	0.624	20	33.78 (2)	< **0.001**	19	4.03 (2)	0.133	19	0.48 (2)	0.788	18	3.56 (2)	0.169
Aggressive driving behavior	Mean age	19	0.81 (1)	0.368	15	9.25 (1)	**0.002**	14	1.30 (1)	0.254	14	0.00 (1)	0.977	16	3.78 (1)	0.052
	Percentage of male drivers	20	0.04 (1)	0.840	16	3.05 (1)	0.081	15	1.84 (1)	0.175	15	0.42 (1)	0.515	17	5.40 (1)	**0.020**
	Driving experience	16	0.11 (1)	0.736	12	0.12 (1)	0.727	11	0.14 (1)	0.710	11	1.22 (1)	0.269	13	0.02 (1)	0.884
	Types of personality measures	20	8.35 (3)	**0.039**	16	3.71 (2)	0.156	15	1.22 (2)	0.544	15	2.16 (2)	0.339	17	0.47 (2)	0.791
Positive driving behavior	Mean age	7	0.04 (1)	0.842	6	0.01 (1)	0.910	6	0.00 (1)	0.996	6	0.01 (1)	0.927	6	0.51 (1)	0.476
	Percentage of male drivers	8	0.01 (1)	0.909	7	0.06 (1)	0.807	7	0.02 (1)	0.899	7	0.09 (1)	0.769	7	0.24 (1)	0.625
	Driving experience	6	2.11 (1)	0.146	5	0.18 (1)	0.675	5	0.01 (1)	0.910	5	0.83 (1)	0.362	5	0.28 (1)	0.598
	Types of personality measures	9	0.12 (2)	0.944	7	0.06 (1)	0.806	7	0.14 (1)	0.713	7	0.58 (1)	0.446	7	1.29 (1)	0.255

Note: k denotes the number of studies included; Q_m denotes the test statistic of presumed moderators.

Table 4
Between-group effects for the associations between the Big Five personality traits and risky driving behaviors.

Personality	Moderator		*k*	Pooled *r* within subgroup (95 % CI)	Q_B
Conscientiousness	Mean age	<35 years	8	–0.10 (–0.27, 0.08)	–
		≥35 years	13	–0.28 (–0.34, –0.23)	5.58*
Agreeableness	Mean age	<35 years	8	–0.12 (–0.23, –0.01)	–
		≥35 years	10	–0.33 (–0.42, –0.23)	7.34**
	Types of personality measures	BFI	10	–0.37 (–0.43, –0.30)	–
		IPIP	5	–0.16 (–0.23, –0.09)	11.58***
		NEOFFI	5	0.02 (–0.12, 0.16)	27.31***
Extraversion	Mean age	<35 years	7	0.15 (0.09, 0.22)	–
		≥35 years	10	–0.02 (–0.11, 0.08)	6.53*
Neuroticism	Mean age	<35 years	6	–0.00 (–0.15, 0.15)	–
		≥35 years	10	0.22 (0.12, 0.31)	6.06*

Note: *k* denotes the number of studies included; *r* denotes the zero-order correlation; CI denotes the confidence interval; Q_B denotes the between-group heterogeneity coefficient; BFI denotes the Big Five Inventory; IPIP denotes the International Personality and Item Pool; NEOFFI denotes the NEO Five-Factor Inventory; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 5
Between-group effects for the associations between the Big Five personality traits and aggressive driving behaviors.

Personality	Moderator		*k*	Pooled *r* within subgroup (95 % CI)	Q_B
Conscientiousness	Types of personality measures	BFI	10	–0.31 (–0.37, –0.25)	–
		IPIP	6	–0.27 (–0.36, –0.18)	0.56
		NEOFFI	3	–0.16 (–0.47, 0.18)	2.01
		NA	1	0.10 (–0.03, 0.22)	12.08***
Agreeableness	Mean age	<35 years	7	–0.29 (–0.37, –0.21)	–
		≥35 years	8	–0.44 (–0.49, –0.38)	9.25**
Neuroticism	Percentage of male drivers	<0.50	6	0.17 (0.06, 0.28)	–
		≥0.50	11	0.31 (0.25, 0.37)	5.40*

Note: *k* denotes the number of studies included; *r* denotes the zero-order correlation; CI denotes the confidence interval; Q_B denotes the between-group heterogeneity coefficient; BFI denotes the Big Five Inventory; IPIP denotes the International Personality and Item Pool; NEOFFI denotes the NEO Five-Factor Inventory; and NA denotes an unspecified personality measure. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

included studies was represented by a polygon at the bottom of the plot, with its width indicating 95 % CI.

To assess the possibility of publication bias (i.e., studies with statistically significant or stronger effect sizes are more likely to be published, which may lead to biased estimation of the summary effect size), both subjective measures (i.e., funnel plots) and objective measures (i.e., Egger's regression test) were used. In a funnel plot, the horizontal axis represents the effect size of each study, and the vertical axis represents the corresponding standard error. The vertical line represents the pooled effect size, and the funnel line indicates that the effect sizes of studies with lower levels of standard error should not deviate too far from the pooled effect size. If the distribution of studies on either side of the vertical line is asymmetric, it may imply a publication bias. To further objectively evaluate publication bias, Egger's regression test was performed, which was indicated to be appropriate for smaller meta-analyses (e.g., with <25 studies; Egger et al., 1997). A statistically significant *Z* value of Egger's regression test indicates a publication bias of studies (Egger et al., 1997). In addition, the trim-and-fill method (Duval and Tweedie, 2000) was used when the subjective and/or objective measures described above indicated a possible publication bias. This method assumes that the asymmetry of funnel plots was attributed to publication bias, so there may be studies with nonsignificant or weak effects that are "missing", in other words, unpublished. Therefore, this method imputes the "missing" studies by creating a mirror image of existing studies and then estimates the adjusted summary effect sizes (Quintana, 2015).

Finally, to determine the sources of study heterogeneity, moderator analyses were conducted to explore potential variables that could moderate the effect sizes. In the current study, we assumed the following categorical moderator variables: (a) mean age (<35 years or ≥35 years), (b) percentage of male drivers (<0.50 or ≥0.50), (c) driving experience (<8 years or ≥8 years), and (d) types of personality measures (the Big Five Inventory (BFI), the International Personality and Item Pool (IPIP), the NEO Five-Factor Inventory (NEOFFI) or other scales). According to Zhang et al. (2019), we determined classification thresholds for mean age and driving experience based on the median values of studies with relevant information. We first conducted moderator analyses based on meta-regression models to test the impact of presumed moderators on effect sizes. Then, to further explore significant moderators, we examined the between-group effect by conducting a test of homogeneity between groups and calculating the between-heterogeneity coefficient (Viechtbauer, 2010). The meta-analyses and moderator analyses were performed in R with the metafor package (Viechtbauer, 2010).

3. Result

The literature search and study selection process are shown in Fig. 1. Initially, 188 records were retrieved through database searching, and 144 records were retained after duplicates were removed, which were screened for titles and abstracts. After that, 73 records were assessed for full text, and 32 records were identified to be eligible for meta-analysis. In addition, 2 records were added by manually searching the reference lists of the included studies. Finally, 34 records were used in our meta-analysis.

3.1. Descriptive statistics

Since we were interested in the relationships between five types of personality traits and three types of driving behavior, descriptive statistics of fifteen pairwise relationships between the Big Five personality traits and driving behaviors are summarized in Table 1 (for more detailed information, please see Appendix A). Among the fifteen pairwise relationships, the relationship between conscientiousness and risky driving behaviors had the most interest, with 24 studies examining this relationship. In comparisons among the Big Five personality traits, conscientiousness attracted relatively more attention across all types of driving behaviors. In comparisons among driving behaviors, more studies have focused on risky driving and aggressive driving, whereas positive driving behaviors have received less attention. There were discrepancies between the number of articles and the number of studies. This is because we extracted two studies from Burtăverde et al. (2016) and Parr et al. (2016), as these articles reported two personality–driving behavior associations using two separate samples. In addition, the sample sizes of individual studies across all pairwise relationships

ranged from 40 to 1181, and the zero-order correlations between the Big Five personality traits and driving behaviors varied considerably across pairwise relationships.

3.2. Meta-analyses

The results of the meta-analyses are shown in Table 2. Risky driving behaviors (see Fig. 2) were negatively associated with conscientiousness (pooled $r = –0.21$, $p < 0.001$), agreeableness (pooled $r = –0.23$, $p < 0.001$) and openness (pooled $r = –0.08$, $p = 0.003$), positively associated with neuroticism (pooled $r = 0.11$, $p = 0.028$), and nonsignificantly associated with extraversion (pooled $r = 0.06$, $p = 0.109$). Similarly, aggressive driving behaviors (see Fig. 3) yielded negative associations with conscientiousness (pooled $r = –0.26$, $p < 0.001$), agreeableness (pooled $r = –0.37$, $p < 0.001$), and openness (pooled $r = –0.07$, $p = 0.002$) and a positive association with neuroticism (pooled $r = 0.26$, $p < 0.001$), whereas they had a nonsignificant association with extraversion (pooled $r = –0.06$, $p = 0.076$). In contrast, positive driving behaviors (see Fig. 4) were positively associated with conscientiousness (pooled $r = 0.30$, $p < 0.001$), agreeableness (pooled $r = 0.32$, $p < 0.001$) and openness (pooled $r = 0.20$, $p < 0.001$), whereas they were nonsignificantly associated with extraversion (pooled $r = 0.08$, $p = 0.107$) and neuroticism (pooled $r = –0.10$, $p = 0.075$). Study heterogeneity tests showed that there were significant unexplained variances in all main effects (all $ps < 0.05$), and there was moderate to large heterogeneity across the studies in all pairwise relationships between personality traits and driving behaviors (I^2 ranged from 57.37 % to 90.42 %), suggesting the necessity of moderator analyses.

Additionally, Egger's regression tests were statistically significant for the association between conscientiousness and risky driving ($Z = 3.63$, $p < 0.001$), the association between agreeableness and aggressive driving ($Z = 2.86$, $p < 0.01$), the association between extraversion.

Additionally, the Egger's regression tests were statistically significant for the association between conscientiousness and risky driving ($Z = 3.63$, $p < 0.001$), the association between agreeableness and aggressive driving ($Z = 2.86$, $p < 0.01$), the association between extraversion and aggressive driving ($Z = 2.62$, $p < 0.01$), and the association between neuroticism and aggressive driving ($Z = –2.26$, $p < 0.05$), indicating the possibility of publication bias in the studies regarding these associations. Then, the trim-and-fill method (Duval and Tweedie, 2000) was used to present the adjusted effect sizes of personality–driving behavior associations. Notably, in the case of the extraversion–aggressive driving association, two studies were imputed to the left of the mean, as revealed in the corresponding funnel plot (see Fig. 5, for all fifteen funnel plots please see Appendix B), which changes the nonsignificant association between extraversion and aggressive driving (pooled $r = –0.06$, $p = 0.076$) to a significant association (pooled $r = –0.08$, $p = 0.017$). Thus, special care needs to be taken in interpreting the result of this association. For the other three associations that might have publication bias, the trim-and-fill method did not impute any study, and thus, the associations remained the same.

3.3. Moderator analysis

The results of the meta-regression models are summarized in Table 3. For risky driving behaviors, mean age yielded a significant moderating effect on the associations between conscientiousness ($Q_m(1) = 5.58$, $p = 0.018$), agreeableness ($Q_m(1) = 7.34$, $p = 0.007$), extraversion ($Q_m(1) = 6.53$, $p = 0.011$) and neuroticism ($Q_m(1) = 6.06$, $p = 0.014$), and the type of personality measure yielded a significant moderating effect on the association between agreeableness and risky driving behaviors ($Q_m(2) = 33.78$, $p < 0.001$). Regarding aggressive driving behaviors, mean age significantly moderated the association between agreeableness and aggressive driving behaviors ($Q_m(1) = 9.25$, $p = 0.002$). The percentage of male drivers significantly moderated the association between neuroticism and aggressive driving behaviors ($Q_m(1) = 5.40$, $p = 0.020$). Types of personality measures significantly moderated the association between conscientiousness and aggressive driving behaviors ($Q_m(3) = 8.35$, $p = 0.039$). Regarding positive driving behaviors, the moderating effects of all presumed variables were not significant (all $ps > 0.05$). Notably, driving experience was not a significant moderator for any personality–driving behavior association.

Moreover, between-group homogeneity tests were conducted for significant moderators, and the results are presented in Table 4 (for personality–risky driving associations) and Table 5 (for personality–aggressive driving associations). As revealed in Table 4, the associations between conscientiousness ($Q_B = 5.58$, $p < 0.05$), agreeableness ($Q_B = 7.34$, $p < 0.01$), and neuroticism ($Q_B = 6.06$, $p < 0.05$) and risky driving behaviors became stronger, whereas the association between extraversion ($Q_B = 6.53$, $p < 0.05$) and risky driving behaviors became weaker as drivers aged. Moreover, the use of personality measures contributed to different strengths of associations between agreeableness and risky driving behaviors, with the BFI showing a stronger association in comparison with the IPIP ($Q_B = 11.58$, $p < 0.001$) and the NEOFFI ($Q_B = 27.31$, $p < 0.001$). Additionally, as revealed in Table 5, the use of personality measures also contributed to different strengths of associations between conscientiousness and aggressive driving behaviors, but these differences were only significant in the comparison between using the BFI and an unspecified scale.[1] The association between agreeableness and aggressive driving behaviors became stronger as drivers aged ($Q_B = 9.25$, $p < 0.01$). In a male-dominant sample (i.e., percentage of male drivers > 0.50), the association between neuroticism and aggressive driving behaviors was stronger ($Q_B = 5.40$, $p < 0.05$).

4. Discussion

The current study systematically reviewed previous research findings on the relationships between the Big Five personality traits and various driving behaviors. Specifically, we classified driving behaviors into two categories, namely, unsafe driving behaviors, including risky and aggressive driving, and positive driving behaviors, based on differences in the intentions behind these driving behaviors and then explored the associations between the Big Five personality traits and each of these three types of driving behaviors. In addition, potential moderators of these relationships were examined.

4.1. Associations between the Big Five personality traits and driving behaviors

Regarding risky and aggressive driving behaviors, our meta-analysis revealed that conscientiousness, agreeableness, and openness were negatively associated with risky and aggressive driving behaviors, while neuroticism was positively associated with risky and aggressive driving behaviors. In contrast, extraversion was not significantly associated with risky or aggressive driving behaviors. It appeared that the relationships between the Big Five personality traits and risky driving behaviors were similar to those of aggressive driving behaviors; however, there were two major differences worth noting.

First, although four dimensions of the Big Five personality traits (except extraversion) were significantly associated with both risky driving behaviors and aggressive driving behaviors, the magnitude of these associations was different. Specifically, the associations between conscientiousness, agreeableness, and neuroticism were stronger for aggressive driving behaviors than for risky driving behaviors. Individuals with higher levels of conscientiousness are more attentive to rules and social obligation norms (Dahlen et al., 2012); thus, they are more likely to follow traffic laws and less likely to exhibit aggressive

[1] This unspecified scale was from Aghabayk et al. (2020). We sent an e-mail to the authors of this article, and the first author replied that he tried but failed to find the measure used in the article.

behaviors toward others. Agreeableness is the dimension of the Big Five personality traits that is most associated with positive interpersonal relationships (Hogan, 1982). Individuals with high levels of agreeableness are characterized by high empathy, trust in others, altruism, and tolerance (McCrae and John 1992). Because they believe it is important to maintain positive interpersonal relationships, they have more tolerance and forgiveness for offensive and provocative behaviors from other drivers and are less likely to exhibit aggressive driving behaviors. Neuroticism is usually associated with general negative affect (McCrae and Costa, 1987). Individuals with higher levels of neuroticism tend to be nervous, anxious, worried, and rigid (McCrae and John 1992). Since most aggressive driving behaviors are inherently related to driver impulsivity and anger (Sârbescu and Maricuţoiu, 2019), it makes sense that drivers who are emotionally unstable and easily angered are at greater risk of exhibiting aggressive behaviors toward other drivers. In addition, the stronger associations between conscientiousness, agreeableness, neuroticism, and aggressive driving behaviors suggested that these three personality traits may be particularly effective indicators for detecting people who are prone to drive in a dangerous manner, especially for identifying those who have harmful intent toward other drivers.

More importantly, although extraversion was not significantly associated with risky and aggressive driving behaviors, the two relationships were not the same. The result of Egger's regression tests showed a significant publication bias in the association between extraversion and aggressive driving behaviors, and their nonsignificant negative association was found to be significant after being adjusted by the trim-and-fill approach (Duval and Tweedie, 2000). Moreover, as revealed by pooled effect sizes and forest plots, relatively more studies found a positive association between extraversion and risky driving behaviors (Baran et al., 2021; Maier et al., 2020; Parr et al., 2016) and a negative association between extraversion and aggressive driving behaviors (Shen et al., 2018; Zhang et al., 2017; Zhang et al., 2018). In addition, one should note that the association between extraversion and unsafe driving behaviors will be even weaker if the results of risky and aggressive driving behaviors are combined. This seems to contradict the results of previous meta-analyses in which one facet of extraversion, sensation seeking, was shown to be a critical predictor of unsafe driving behaviors (Sârbescu and Rusu, 2021; Zhang et al., 2019). However, the difference may be explained by the principle of compatibility, that is, the association between two constructs is stronger when they match in specificity or generality (Beus et al., 2015; Harrison et al., 2006). Since the broader personality trait extraversion also includes other dimensions that may be less strongly, or even nonsignificantly, associated with unsafe driving behaviors, while sensation seeking and unsafe driving behaviors match better in terms of specificity, it makes sense that sensation seeking is more strongly associated with dangerous driving behaviors than the broader personality trait extraversion.

We confirmed positive associations of positive driving behaviors with conscientiousness, agreeableness and openness. In contrast, extraversion and neuroticism were not significantly associated with positive driving behaviors. One might note that these results were generated from a limited number of empirical studies (i.e., <10); however, the findings of these significant (Ge et al., 2020; Harris et al., 2014; Shen et al., 2018; Taubman-Ben-Ari and Yehiel, 2012; Wang et al., 2018; Xu et al., 2018) and nonsignificant (Ge et al., 2020; Mahembe and Samuel, 2016; Taubman-Ben-Ari and Yehiel, 2012; Wang et al., 2018; Xu et al., 2018) associations were generally consistent among existing studies. In addition, the significant associations between conscientiousness, agreeableness, openness and positive driving behaviors revealed in some studies were moderate in size (Harris et al., 2014; Shen et al., 2018). However, given the great value of positive driving behaviors in promoting traffic safety (Özkan and Lajunen, 2005; Shen et al., 2018), more research on personality trait predictors of positive driving behaviors is recommended.

Overall, this study comprehensively integrated the findings of previous studies through a quantitative approach and revealed the relationships between the Big Five personality traits and various driving behaviors, which, to some extent, addressed the controversies of previous studies. In addition to theoretical contributions, our findings also provide valuable insights for practice. It was shown that people with low levels of conscientiousness, agreeableness, and openness or high levels of neuroticism were more likely to engage in unsafe driving behaviors. Therefore, specific intervention programs can be designed to educate people with these characteristics and help them reduce dangerous driving behaviors. Moreover, people with low levels of conscientiousness, agreeableness, and openness were found to exhibit fewer positive driving behaviors. Thus, they may also need to participate in other programs that emphasize the importance of positive driving behaviors in improving road traffic safety and teach them how to drive in a more positive way. In addition, since extraversion was found to be associated with neither unsafe driving behaviors nor positive driving behaviors, while one of its facets, sensation seeking, was confirmed to be an effective predictor of dangerous driving behaviors (Sârbescu and Rusu, 2021; Zhang et al., 2019), educational and interventional programs targeting drivers with high levels of sensation seeking may be more effective in preventing or reducing their negative impact on road safety.

4.2. Moderators

Several moderators of the associations between the Big Five personality traits and various driving behaviors were identified in this study. First, age was shown to be an effective moderator of the relationships between the Big Five personality traits and risky and aggressive driving behaviors. Compared to younger drivers, older drivers with low levels of conscientiousness and agreeableness or high levels of neuroticism were more likely to engage in risky driving behaviors, and older drivers with low levels of agreeableness also exhibited more aggressive driving behaviors. A possible explanation was that younger drivers were more likely to be influenced by other factors, such as driving skills, driving environment and other driving-specific personality traits (Shope, 2006). For example, Zhang et al. (2016) found that driving anger was a stronger predictor of risky driving behaviors among younger drivers than among older drivers. Therefore, it was reasonable that the associations between conscientiousness, agreeableness, neuroticism, and risky driving behaviors, as well as the association between agreeableness and aggressive driving behaviors, were stronger among older drivers. In contrast, extraversion was only significantly positively associated with risky driving behaviors among younger drivers but not among older drivers. People with high levels of extraversion were characterized as outgoing, bold, and fun-loving (McCrae and Costa, 1987). Some researchers found that younger drivers perceived lower levels of risk for dangerous driving behaviors, and they were more likely to enjoy these driving behaviors (Rhodes and Pivik, 2011). Furthermore, for younger drivers, extraversion was shown to be an effective predictor of risky driving behaviors such as using a smartphone while driving (Luria, 2018) and other distracting driving behaviors (Braitman and Braitman, 2017). Therefore, it made sense that extraversion was a stronger predictor of risky driving behaviors for younger drivers.

Regarding the moderating effect of gender, we found that the positive association between neuroticism and aggressive driving behaviors was stronger in male-dominant samples. People with high levels of neuroticism are described as irritated, anxious, impatient, and tense (Goldberg, 1992; McCrae and Costa, 1987) and are more likely to adopt inappropriate coping strategies, such as hostile reactions (McCrae and Costa, 1987). Previous studies found that male drivers had higher levels of dispositional aggressiveness (Perepjolkina and Renge, 2011) and were more likely to experience negative emotions, such as anger, in some driving-related situations (Berdoulat et al., 2013). In addition, a large number of studies have shown that aggressive driving behaviors are more frequent among men than among women (Dahlen and White,

2006; Sârbescu et al., 2014; Shinar and Compton, 2004). Thus, male drivers may be more susceptible to neuroticism and exhibit more aggressive driving behaviors.

Another significant moderator of the associations between the Big Five personality traits and driving behaviors is the type of personality measure. Specifically, the negative associations between agreeableness and risky driving behaviors and between conscientiousness and aggressive driving behaviors were stronger when personality traits were measured with the BFI (John and Srivastava, 1999) and weaker when measured with the IPIP (Goldberg 1992). When personality traits were measured with the Revised NEO Personality Inventory (NEO PI-R; Costa and McCrae, 1992), these associations were even weaker, such that the results changed from significant to nonsignificant. These differences in results may be due to the different psychometric properties of different measures of the Big Five personality traits. Although the Big Five personality traits model is a widely accepted and used personality trait model, researchers have not yet reached a consensus on its measurement. Although all measures mentioned above (Costa and McCrae, 1992; Goldberg 1992; John and Srivastava, 1999) have been confirmed to be valid tools for measuring the Big Five personality traits, the impact of the type of personality measure on the findings of the relationship between the Big Five personality traits and driving behaviors is noteworthy. Furthermore, from a practical perspective, since we found stronger negative associations between conscientiousness and agreeableness measured by the BFI (John and Srivastava, 1999) and unsafe driving behaviors, the BFI could be used as an appropriate measure of drivers' Big Five personality traits in situations where the Big Five personality traits are used as predictors of unsafe driving behaviors, such as driver selection and screening for risky drivers.

In contrast to our expectations, driving experience was not a significant moderator of the relationship between the Big Five personality traits and any driving behavior. Furthermore, we did not find any significant moderating variables for the relationship between the Big Five personality traits and positive driving behaviors. However, one should note that these results were derived from a limited number of studies that explicitly reported information on driving experience or investigated the association between the Big Five personality traits and positive driving behaviors. Therefore, future studies are required to elaborate on their samples to provide essential information for subsequent analysis. In addition, the relationship between personality traits and positive driving behaviors and other potential moderators of this relationship warrant more attention.

4.3. Limitations and future directions

The current study has several limitations. First, the results of this study are based on correlational data, and therefore, no causal inferences can be made. Moreover, most of the included studies used self-reported measures of driving behaviors, and only a few studies measured risky driving behaviors in a relatively objective way, such as using driving simulators (Valero-Mora et al., 2021); therefore, future studies should consider measuring driving behaviors through more objective data, such as data from driving simulators or police-reported violations. In addition, some studies were excluded from this study because they did not report the information needed for meta-analysis, such as zero-order correlations between variables and the instruments used to measure the variables. Therefore, conclusions regarding the associations between the Big Five personality traits and various driving behaviors, particularly those regarding positive driving behaviors, are based on limited research and need to be interpreted with caution. For similar reasons, only a small number of potential moderators were examined in this study, and the number of studies in certain groups of the subgroup analysis was relatively small. Given the increasing awareness of the importance of research transparency and reproducibility in recent years, we strongly recommend that future studies honestly and clearly report necessary information, such as sample characteristics and experimental design details, which would effectively facilitate subsequent comprehensive quantitative analyses. Finally, although previous research on the relationships between the Big Five personality traits and various driving behaviors has been synthesized and some controversies have been addressed in the present study, we still lack sufficient understanding of the mechanisms underlying these relationships. In fact, only a few studies have provided and tested some possible explanations (Qu et al., 2022; Zhang et al., 2018). Thus, the mechanisms of the effects of the Big Five personality traits on driving behaviors remain to be explored in the future.

5. Conclusions

Although there is a large body of research on the relationships between the Big Five personality traits and driving behaviors, researchers have failed to reach a consensus on their associations. The present study systematically reviewed and quantitatively synthesized the results of existing research on the relationship between the Big Five personality traits and risky, aggressive, and positive driving behaviors. The results showed that conscientiousness, agreeableness, and openness were negatively associated with risky and aggressive driving behaviors, whereas neuroticism was positively associated with them. We found that positive driving behaviors were positively associated with conscientiousness, agreeableness, and openness. In addition, age, gender, and the type of personality measure were found to be moderators of these associations. This study not only theoretically reconciles previous debates about the relationships between the Big Five personality traits and various driving behaviors but also provides valuable insights into relevant practice. For example, the Big Five personality traits could be useful indicators for selecting safe drivers and screening risky drivers. In addition, our findings may help policy-makers and intervention program designers adopt effective strategies to reduce unsafe driving behaviors and improve the road traffic environment.

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CRediT authorship contribution statement

Xiaohui Luo: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Yan Ge:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing. **Weina Qu:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Study characteristics.

ID	Study	Personality	Measures for personality	Driving behaviors	Measures for driving behaviors	Participants	Sample size	Mean Age (Years)	Percentage of Male Participants (%)	Mean Driving experience (Years)
1	Valero-Mora et al., 2021	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	Average speed recorded by driving simulators	University students	91	22.50	43.0	3.75
2	Herrero-Fernández, 2021	Conscientiousness	The NEO Five-Factor Inventory (NEOFFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Multidimensional Driving Style Inventory	Licensed drivers	228	38.64	45.2	15.11
3	Baran et al., 2021 (Sample 1)	Conscientiousness	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	The Multidimensional Driving Style Inventory	Car drivers	152	39.22	46.0	15.74
3	Baran et al., 2021 (Sample 2)	Extraversion	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	The Multidimensional Driving Style Inventory	Car drivers	154	32.27	60.0	11.15
4	Kalantari et al., 2021	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	Cell phone use while driving	Licensed drivers	255	30.73	66.3	8.87
5	Maier et al., 2020	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Risky driving behavior	Smartphone use while driving	Licensed drivers	273	28.50	60.3	NA
6	Aghabayk et al., 2020	Conscientiousness	NA	Aggressive driving behaviorRisky driving behavior	The Driver Behavior Questionnaire	Taxi drivers	245	46.80	100.0	NA
7	Ge et al., 2020	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Driver Behavior QuestionnaireThe Driver Behavior QuestionnaireThe Positive Driving Behaviors Scale	Licensed drivers	299	35.07	60.9	6.36
8	Sârbescu and Maricuţoiu, 2019	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behavior	The Driving Anger Expression scale	Licensed drivers	91	31.08	70.3	9.66
9	Linkov et al., 2019	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	Average speed recorded by driving simulators	Truck drivers	40	40.40	100.0	NA
10	Wang et al., 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Driver Behavior QuestionnaireThe Driver Behavior QuestionnaireThe Positive Driving Behaviors Scale	Licensed drivers	296	35.05	60.8	6.37
11	Zhang et al., 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behavior	The Dula Dangerous Driving Index	Licensed drivers	413	40.37	68.3	8,12
12	Watling, 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality	Risky driving behavior	Risk taking scale	Licensed drivers	293	39.20	40.9	22.71

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(*continued*)

ID	Study	Personality	Measures for personality	Driving behaviors	Measures for driving behaviors	Participants	Sample size	Mean Age (Years)	Percentage of Male Participants (%)	Mean Driving experience (Years)
			Item Pool (IPIP)							
13	Shen et al., 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Driver Behavior QuestionnaireThe Driver Behavior QuestionnaireThe Positive Driving Behaviors Scale	Licensed drivers	421	40.34	67.9	NA
14	Xu et al., 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Driver Behavior QuestionnaireThe Driver Behavior QuestionnaireThe Positive Driving Behaviors Scale	Licensed drivers	295	35.13	60.7	6.37
15	Riendeau et al., 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The NEO Five-Factor Inventory (NEOFFI)	Risky driving behavior	Number of speed exceedancesAverage speed	Undergraduates and older adults	114	NA	45.6	NA
16	Luria, 2018	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Risky driving behavior	Smartphone screen touches while driving	Young drivers	221	19.30	65.0	NA
17	Zhang et al., 2017	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behavior	The Driver Aggression Indicators Scale	Licensed drivers	422	NA	67.8	NA
18	de Vries et al., 2017	ConscientiousnessAgreeablenessExtraversionOpenness	The Big Five Inventory (BFI)	Risky driving behavior	Number of speed violationsCumulative duration of speed violations	Truck drivers	49	NA	100.0	NA
19	Burtăverde et al.,2016 (Sample 1)	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behavior	The Driving Anger Expression scale	Undergraduate students	274	25.08	20.8	5.73
19	Burtăverde et al., 2016 (Sample 2)	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behavior	The Driving Anger Expression scale	Amateur drivers	95	31.47	52.6	10.3
20	Mahembe and Samuel, 2016	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Positive driving behavior	The Positive Driving Behaviors Scale	Taxi drivers	203	NA	100.0	NA
21	Parr et al.,2016 (Sample 1)	ConscientiousnessAgreeablenessOpenness	The Big Five Inventory (BFI)	Risky driving behavior	Questionnaire Assessing Distracted Driving	Teens	47	17.38	40.0	NA
21	Parr et al.,2016 (Sample 2)	ExtraversionOpenness	The Big Five Inventory (BFI)	Risky driving behavior	Questionnaire Assessing Distracted Driving	Older adults	72	72.29	44.0	NA
22	Starkey and Isler, 2016	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International	Risky driving behavior	Driver Risk Taking Questionnaire	Male drivers	78	NA	100.0	NA

(*continued on next page*)

(*continued*)

ID	Study	Personality	Measures for personality	Driving behaviors	Measures for driving behaviors	Participants	Sample size	Mean Age (Years)	Percentage of Male Participants (%)	Mean Driving experience (Years)
			Personality Item Pool (IPIP)							
23	Chraif et al., 2016	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behavior	Aggressive driving behavior test	Licensed drivers	293	31.34	86.0	14.34
24	Javadi et al., 2015	ConscientiousnessAgreeableness	The NEO Five-Factor Inventory (NEOFFI)	Aggressive driving behaviorRisky driving behavior	The Driver Behavior Questionnaire	Young male drivers	253	NA	100.0	NA
25	Qu et al., 2015	ConscientiousnessAgreeablenessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behavior	The Dula Dangerous Driving Index	Licensed drivers	295	37.34	50.2	NA
26	MacKenzie et al., 2015	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Risky driving behavior	Risk-taking driving scale	Licensed drivers	293	39.15	41.2	NA
27	Harris et al., 2014	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Positive driving behavior	The Prosocial and Aggressive Driving Inventory	Undergraduate students	1181	NA	30.7	NA
28	Devarasetty et al., 2014	Conscientiousness	The International Personality Item Pool (IPIP)	Risky driving behaviorPositive driving behavior	The Multidimensional Driving Style Inventory	Licensed drivers	132	NA	NA	NA
29	Dahlen et al., 2012	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behavior	The Driving Anger Expression scale	Licensed drivers	308	37.89	41.9	21.08
30	Taubman-Ben-Ari and Yehiel, 2012	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behaviorPositive driving behavior	The Multidimensional Driving Style Inventory	Light vehicles drivers	320	35.13	46.9	14.92
31	Lustman, 2011	ConscientiousnessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behaviorRisky driving behavior	The Dula Dangerous Driving Index	Undergraduate students	117	22.46	17.9	4.5
32	Jovanović et al., 2011	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The NEO Five-Factor Inventory (NEOFFI)	Aggressive driving behavior	The Driving Anger Expression scale	Licensed drivers	260	32.50	52.7	NA
33	Dahlen and White, 2006	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The International Personality Item Pool (IPIP)	Aggressive driving behaviorRisky driving behavior	Driving Survey	Undergraduate students	312	NA	28.8	NA
34	Britt and Garrity, 2006	ConscientiousnessAgreeablenessExtraversionOpennessNeuroticism	The Big Five Inventory (BFI)	Aggressive driving behavior	Self-developed items	Undergraduate students	164	19.00	39.0	NA

Appendix B. Funnel plots of all personality–driving behavior associations.

Figs. B1–B3

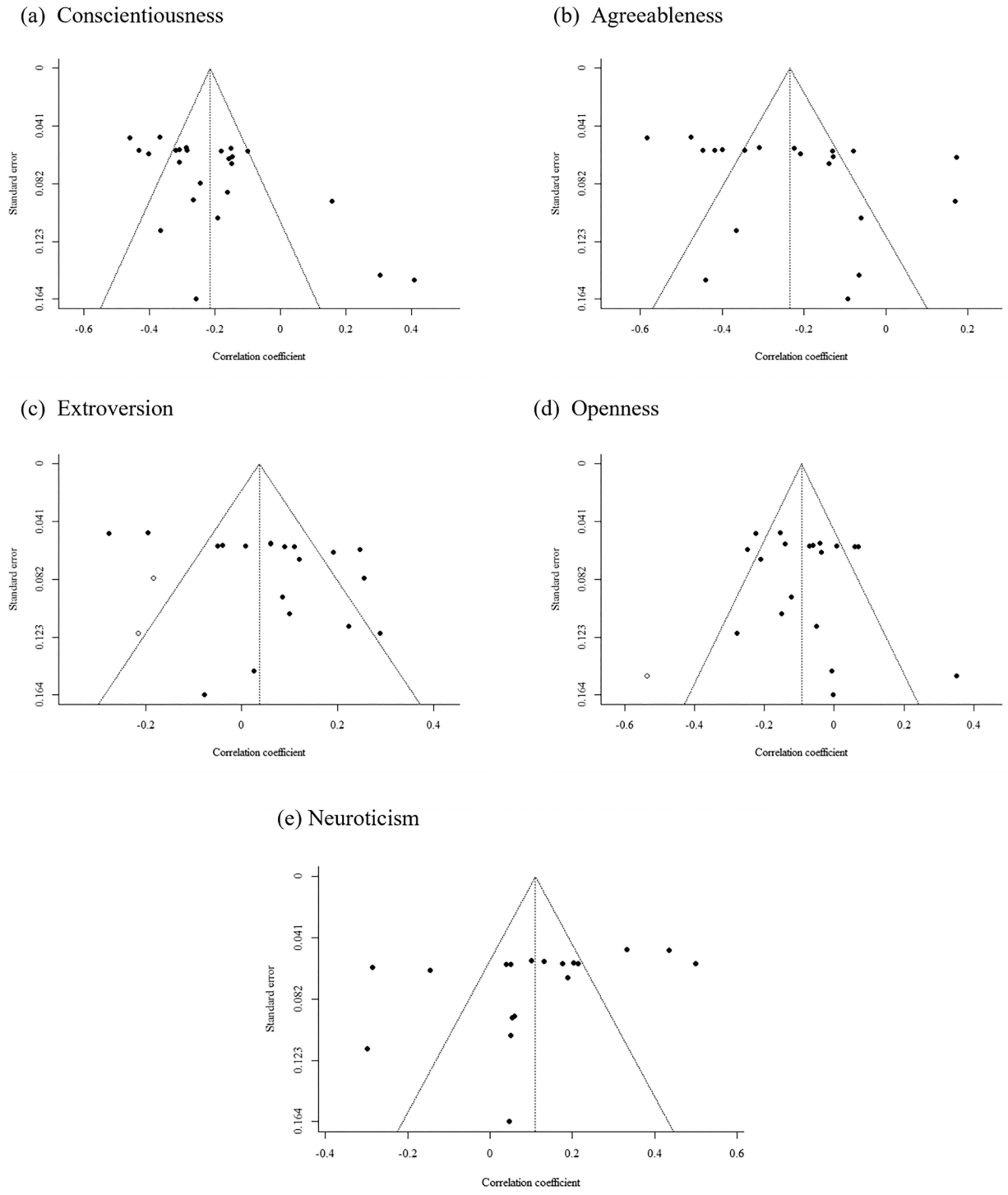

Fig. B1. Publication bias funnel plot for the studies regarding the associations between the Big Five personality traits and risky driving behaviors. *Note*. Filled dots denote observed studies and hollow dots denote imputed studies.

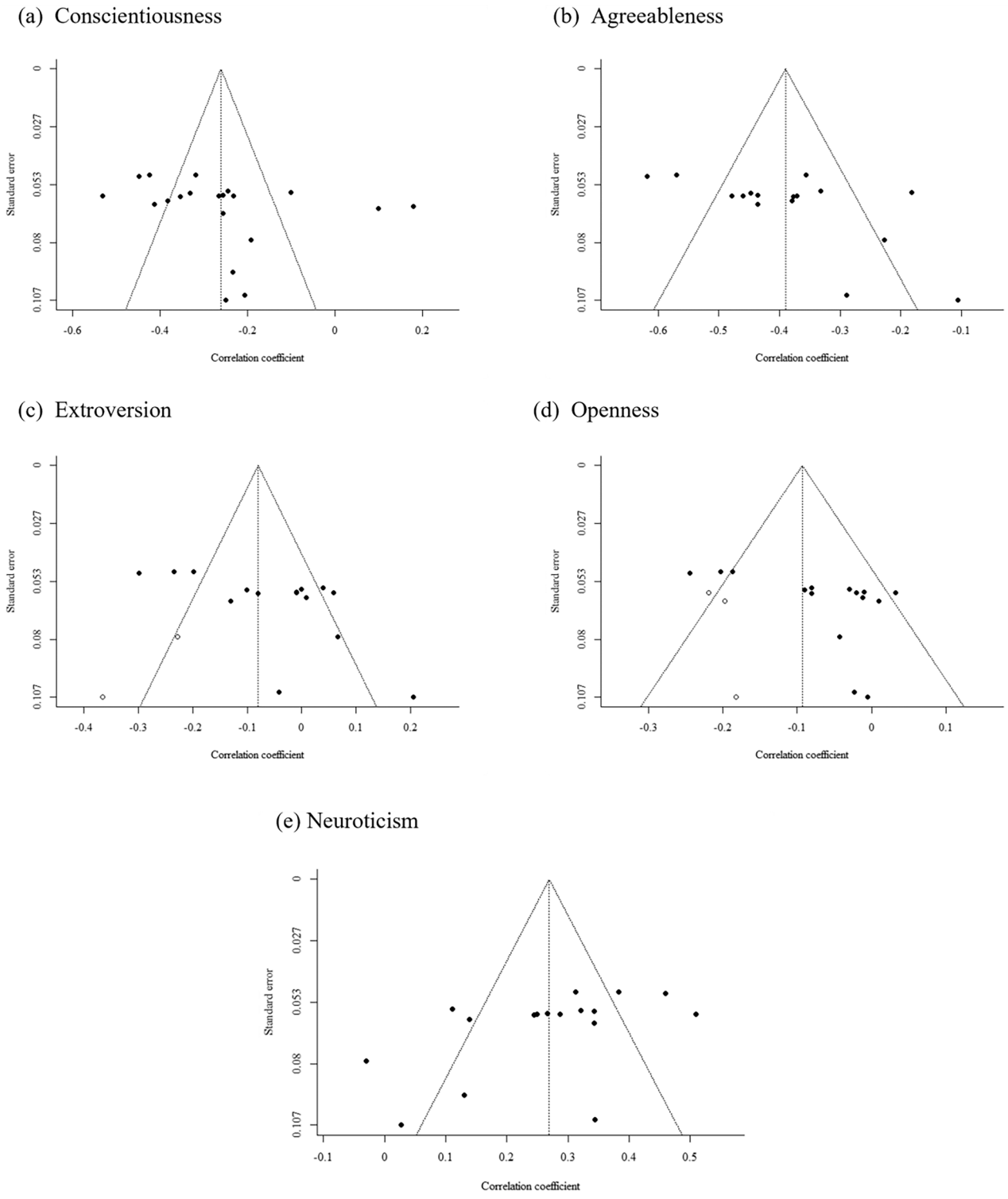

Fig. B2. Publication bias funnel plot for the studies regarding the associations between the Big Five personality traits and aggressive driving behaviors. *Note*. Filled dots denote observed studies and hollow dots denote imputed studies.

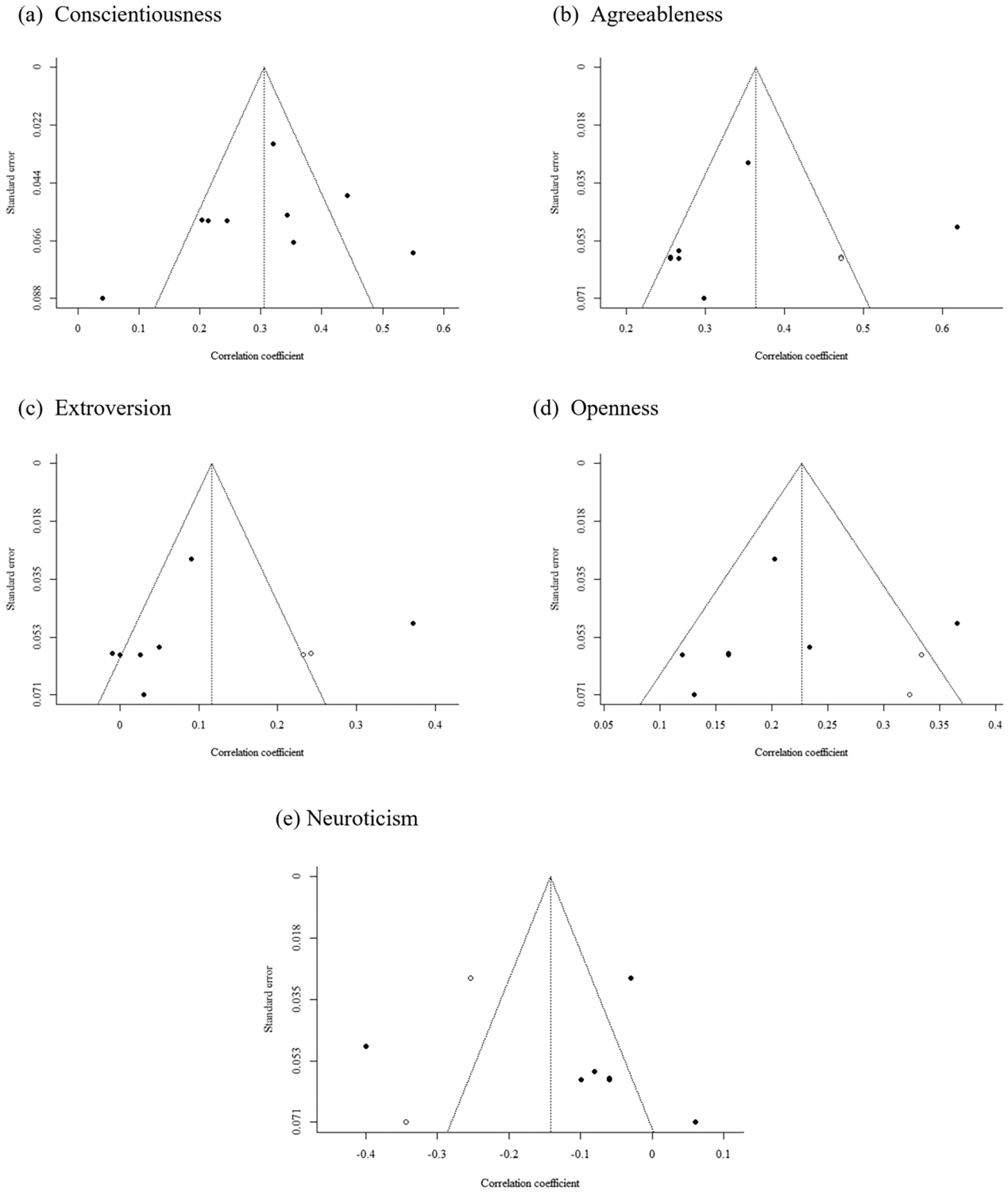

Fig. B3. Publication bias funnel plot for the studies regarding the associations between the Big Five personality traits and positive driving behaviors. *Note.* Filled dots denote observed studies and hollow dots denote imputed studies.

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