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# A planning intervention to quit smoking in single-smoking couples: does partner involvement improve effectiveness?

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## ABSTRACT

**Objective:** Smoking cessation interventions that use implementation intentions have shown promising results. Implementation intentions are if-then plans that specify certain behaviour within a situational context. This study examines whether dyadic planning (i.e., involving a non-smoking partner) is more effective than individual planning in quitting smoking.

**Design:** This longitudinal single-blind randomized controlled trial involves a baseline questionnaire, end-of-day measurements for three weeks, and a follow-up questionnaire after three months. Single-smoking couples were randomized to a dyadic or individual planning condition. After the intervention, which 176 couples received, smokers attempted to quit smoking, and the diary measurements started.

**Main Outcome Measures:** smoking abstinence, number of cigarettes smoked and relationship satisfaction.

**Results:** At follow-up, both planning groups showed similar quit rates (33%, dyadic; 30%, individual) and a similar significant decline in number of cigarettes smoked (almost 50%). For most smokers, the smoking pattern shown in the diary seemed to be indicative of smoking behaviour at follow-up. Relationship satisfaction declined minimally, in both intervention groups and in both smokers and partners.

**Conclusion:** The involvement of a non-smoking partner in the planning did not increase its effectiveness. However, couple participation and daily measurements during a quit attempt could be important components of future interventions.

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Couple; Non-smoking  
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controlled trial;  
Implementation intentions

## Introduction

Tobacco smoking is still a pressing health issue worldwide, with a percentage of smokers as high as 20% in 2015 of the world's population aged 15 years and older (Geneva: World Health Organization, 2018). Although the smoking rates have shown a small

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downward trend over the past years, successful quitting remains difficult, indicating a need for effective smoking cessation interventions. One promising method is the use of implementation intentions (Armitage, 2016). Furthermore, the literature shows that a non-smoking partner has a beneficial influence on smoking reduction and cessation (e.g., Homish & Leonard, 2005). Therefore, this study examines whether combining these two, by actively involving a non-smoking partner in a planning intervention, might increase the intervention's effectiveness for smoking cessation.

In general, interventions that use implementation intentions are effective in establishing a desired change in health behaviour (Hagger & Luszczynska, 2014). Implementation intentions are if-then plans in which planned behaviours are specified within a situational context (Gollwitzer & Sheeran, 2006). An example of an implementation intention is 'when I wake up and crave a cigarette, I'm going to drink coffee instead.' The use of implementation intentions can decrease smoking habits (i.e. smoking routinely), the number of cigarettes smoked, nicotine dependence as well as increasing the quit rate (Armitage, 2008, 2016). There are indications that encouraging partner involvement in a planning intervention could increase its effectiveness (Prestwich et al., 2005).

Health behaviour always occurs in a social context. Spouses influence each other's health behaviour, including smoking (Falba & Sindelar, 2007). Smokers with a non-smoking partner use less tobacco (Homish & Leonard, 2005), more often try to quit (Chen, White, & Pandina, 2001; Dollar, Homish, Kozlowski, & Leonard, 2009), and are more likely to succeed when trying (Margolis & Wright, 2016) compared to smokers who have a smoking partner. Additionally, non-smokers are more willing to support quit attempts compared to smoking partners (VanDellen, Boyd, Ranby, MacKillop, & Lipkus, 2016), and spouse support is related to smoking fewer cigarettes, both before and during a self-set quit attempt (Scholz et al., 2016). Of all smokers, around 35% are in a relationship with a non-smoker (Margolis & Wright, 2016; Rüge et al., 2008) and could enjoy this beneficial influence on quitting or reducing smoking.

This study involves non-smokers in their partners' quit attempt, by asking the couple to create implementation intentions for the smoker together (i.e. dyadic planning). The non-smoking partner can help by discussing smoking habits and creating plans for the smoker. This can be distinguished from collaborative planning, where all plans must be executed together (Prestwich et al., 2012). However, participants were allowed to develop collaborative plans for times they spend together with their partner. By involving the partner in the planning intervention, the non-smoker is not merely a support provider, but part of a team where the quit attempt is considered a dyadic effort or challenge.

Creating plans together has been examined before in the context of other health behaviours. Dyadic planning was not more successful than individual planning in increasing daily physical activity (Knoll et al., 2017), nor in integrating pelvic-floor exercise into daily life after prostatectomy (Burkert, Scholz, Gralla, Roigas, & Knoll, 2011). On the other hand, the dyadic planning group did show higher levels of maintenance of these exercises over time (Keller et al., 2015) as compared to the individual planning group. In addition, plans to increase physical exercise, formulated in a dyadic planning condition, were more strongly related to actual plan enactment, compared to those formulated in an individual planning condition (Keller et al., 2017). Given the importance of plan enactment for smoking cessation (de Vries, Eggers, & Bolman,

2013), we hypothesize that dyadic planning will be more effective for achieving a successful quit attempt than individual planning.

A by-product of dyadic planning is that it can prevent or act as a buffer for the effects of partners' negative control over behaviour change (Burkert et al., 2011). A quit attempt can be a stressful period for couples, since anger, irritability and frustration are elevated in smokers (Hughes, 2007). Conflicts or other negative partner behaviours might arise, that in turn, could hinder successful smoking cessation (Palmer, Baucom, & McBride, 2000). Dyadic planning could act as a buffer for these negative partner behaviours (Burkert et al., 2011) and foster (or protect) the relationship satisfaction of both members of the couple, because the team effort might decrease the frequency or impact of negative behaviours.

In sum, this randomized controlled trial examines whether dyadic planning is more effective than individual planning in quitting smoking in smokers with a non-smoking partner. We hypothesize that in the dyadic planning group, the proportion of abstainers will be larger and that quitters who relapse will report fewer cigarettes smoked at follow-up as compared to the individual group. Additionally, we hypothesize that both members of the couples in the dyadic planning group report a higher relationship satisfaction in the first three weeks after the quit attempt as well as after a follow-up period of three months, as compared to both members of the couple in the individual group.

## Methods

This study is part of a larger single-blind randomized controlled trial (i.e., individual versus dyadic planning), consisting of a baseline measurement, a three-week diary period and a follow-up measurement after three months. For a detailed description of the study protocol see Buitenhuis et al. (2018). The study was approved by the Ethical Committee of Psychology of the University of Groningen (16237-O) and complies with the Dutch law on Medical Research involving human subjects. The trial was registered in the Netherlands Trial Register ([www.trialregister.nl/trial/5999](http://www.trialregister.nl/trial/5999)).

### *Participants and procedure*

Participants were cohabiting couples who had been in a romantic relationship for at least one year, of which one spouse had to be a regular smoker (i.e., smoking cigarettes every day or multiple days per week), while the other was a non-smoker. Exclusion criteria were pregnancy, aged younger than 18 and not owning a mobile phone with access to internet. Participants were recruited through the use of flyers and social media from April 2017 to July 2018.

Couples could sign up through our website, where they were asked about their smoking status and email addresses. After the first eligibility assessment (e.g., being a single-smoking couple), the couples were randomized and received a link to the baseline questionnaire including the informed consent form. The randomization was blinded, and participants were not aware of the presence of different intervention groups (i.e., an individual versus dyadic planning group). At the end of the

questionnaire, participants were asked to fill in their home address and phone number. By post, they received a package including an information letter, an instruction manual with frequently asked questions about the diary, and a (dyadic or individual) planning sheet in a closed envelope.

A few days later, participants were called to make an appointment for the telephonic intervention. Directly after the intervention the couples received instructions about the diary from one of the researchers. Both members of the couple had to register their phone to receive text messages ([www.surveysignal.com](http://www.surveysignal.com)) and practice with an example questionnaire. The diary period, and consequently the quit date, started the day after the intervention. Every evening, for 21 days, both members of the couple received a text message with a link to the questionnaire. Three months after the end of the diary period, couples received an email with a link to the follow-up questionnaire. At the end of this questionnaire, participants were debriefed. When the follow-up was not filled in, the debriefing was sent by email.

Figure 1 shows the flowchart of the participating couples. In total, 948 individuals clicked the link to the online survey. However, 177 cases (19%) were excluded because they were completely missing, or did not give informed consent at the beginning of the questionnaire. A subsequent 127 duplicates (17%) were excluded (some participants filled in the questionnaire more than once). Participants' first and/or most complete data row was included in the analyses. In the end, baseline information of 644 individuals (327 smokers, 317 partners) was analysed. Table 1 shows baseline characteristics of all participants in both intervention groups. Randomization was successful as smokers and partners in both groups had comparable baseline characteristics (all *p*-values exceeded .05).

Only couples of which both spouses completed the baseline questionnaire continued to the next phase. The next phase started with 356 participants who received the intervention, resulting in 352 individuals (176 smokers and 176 partners) who started the diary. The smokers and partners who received the intervention were not significantly different from the smokers who dropped-out before the intervention in number of cigarettes smoked and relationship satisfaction and were equally distributed between intervention groups (all *p*-values exceeded .05).

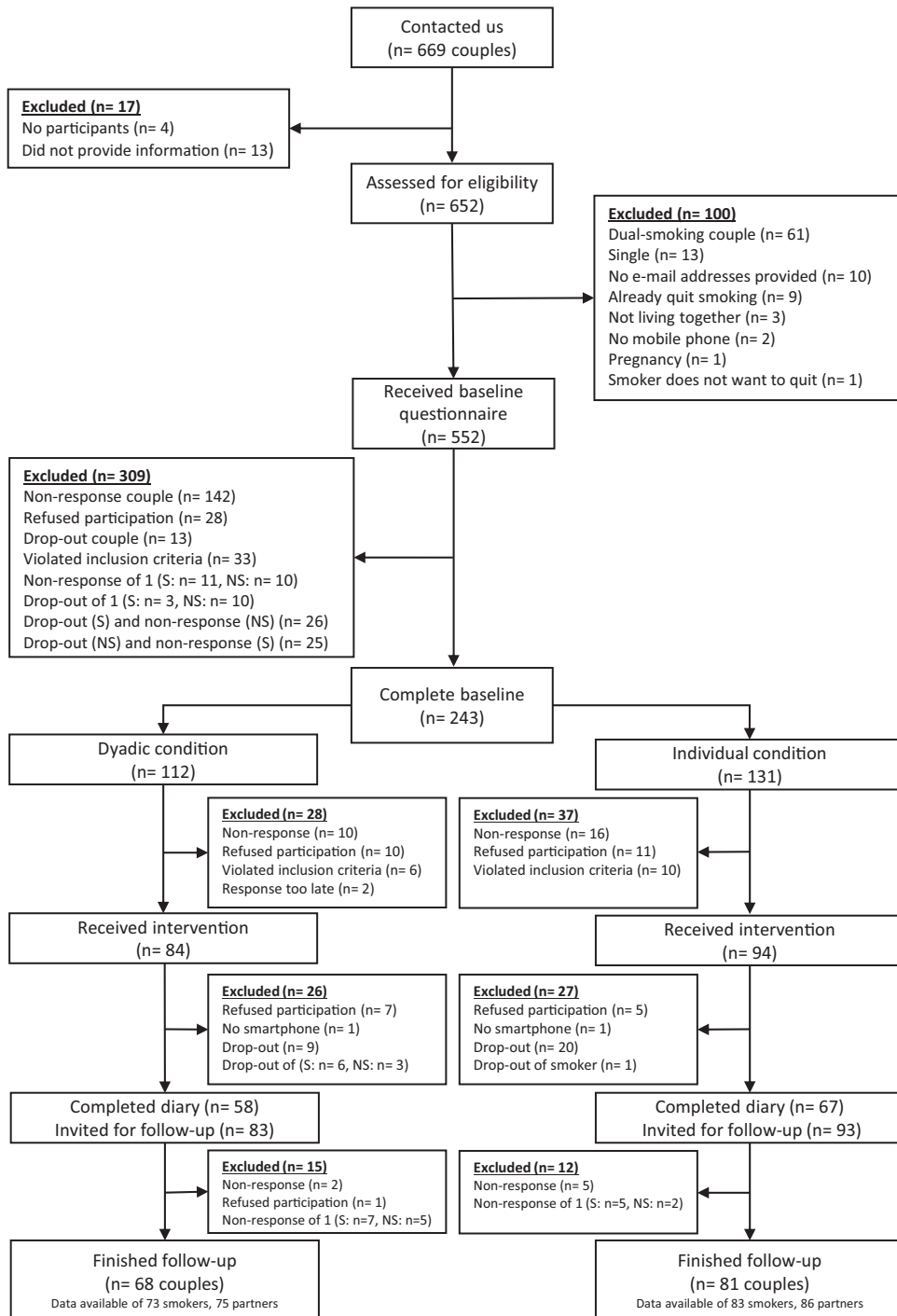
Out of 21 diary days, the individual intervention group missed on average 5.16 days, which was similar to 4.95 in the dyadic intervention group ( $t(350) = .343, p = .732$ ). Overall, the participating couples showed a completion rate of 76% ( $n = 5611$  of 7392 possible diary days).

All 352 participants, who received the intervention, were invited to fill in the follow-up questionnaire. In total, 156 smokers (89%) and 162 partners (92%) filled in the follow-up questionnaire. (Former) Smokers with or without follow-up were not significantly different in number of cigarettes smoked, relationship satisfaction and were equally distributed between intervention groups (all *p*-values exceeded .05).

## **Intervention**

### ***Dyadic planning intervention***

In the dyadic planning group, the non-smoking partner was involved in the intervention. The couple opened the envelope containing the planning sheet together, at



**Figure 1.** Flow-chart of the study sample. N represents the number of couples.

**Table 1.** Mean baseline characteristics for the dyadic and individual planning group.

Variables	Dyadic planning group		Individual planning group	
	Smokers ( <i>n</i> = 145)	Partners ( <i>n</i> = 135)	Smokers ( <i>n</i> = 167)	Partners ( <i>n</i> = 150)
Male (%)	50.3	42.2	46.1	38.0
Age (years)	38.2 (11.7, 18-72)	39.2 (11.5, 20-71)	38.4 (11.4, 18-65)	37.9 (11.7, 19-70)
Relationship duration (years)*	12.0 (10.7, 1.0-49.3)	12.5 (10.8, 1.3-52.1)	12.9 (10.7, 1.0-47.0)	12.2 (10, 1.1-45.4)
Number of cigarettes smoked**	16.8 (9.2, 1-52)	–	17.0 (8.7, 2-55)	–
Relationship satisfaction***	6.8 (1.12, 1.3-8.0)	6.7 (1.14, 2.3-8.0)	6.8 (1.24, 0.8-8.0)	6.8 (1.09, 2.4-8.0)

Note. \*DP: 134 partners, \*\*DP: 137 smokers, IP: 158 smokers, \*\*\*DP: 136 smokers and 125 partners, IP: 154 smokers and 148 partners. Standard deviations and ranges are in brackets.

home, with guidance from a researcher during a telephone call. The planning sheet was originally designed to enhance pelvic floor exercise among prostate cancer survivors (Burkert et al., 2011). It was adapted to suit the topic of smoking cessation. The first step in the intervention was to write down moments that the smoker usually smokes a cigarette (e.g., after dinner, when going out). The partner could help by giving suggestions. The researcher asked questions to assure most moments were written down (e.g., ‘when is your first or last cigarette of the day?’) and actively involved the partner when necessary (e.g., ‘do you know of other moments that are not mentioned yet?’). The second step was to create implementation intentions for these expected difficult moments. The couples were asked to write down concrete actions (implementation intentions) on how to prevent smoking at those moments (e.g., going for a walk instead). When necessary, the researcher could help by giving suggestions. Lastly, the couples indicated for each plan how feasible they think it is. Next day’s date was written down as the quit date and the couples signed the plan to make it official and sent a copy (or photo) to the researcher.

### Individual planning intervention

Before opening the envelope and starting with the intervention, the non-smoking partner was asked to leave the room by the researcher and not to return before the diary instruction. The planning sheet contained the same steps as the dyadic planning sheet, only the smoker filled it in without help from their partner.

## Measures

### Smoking behaviour

During the diary period, (former) smokers were asked daily whether they had smoked that day: ‘Did you smoke today (including one puff)? (Lüscher, Stadler, & Scholz, 2017). If yes, they were asked how many cigarettes they had smoked (1, 2, 3, 4, 5, >5). The proportion of weekly abstainers was determined by reporting no smoking for either 7, 14 or 21 days in a row (i.e., no missing data is allowed). The number of cigarettes at baseline and follow-up was measured by asking the number of cigarettes the participant smoked on average per day in the last seven days (Ochsner et al., 2015). Additionally, at follow-up, smokers who relapsed after the intervention, could indicate their current smoking behaviour (i.e., ‘I smoked just a few cigarettes since the intervention’, ‘I started smoking daily, but quit again’, ‘I am smoking, but not daily’, ‘I am smoking daily’). Smokers who reported smoking just a few cigarettes since the

intervention or quit again, and reported zero cigarettes at follow-up were also considered quitters.

### *Diary smoking patterns*

Participants were considered quitters when they reported non-smoking for at least 18 of the 21 diary days (three missings and/or relapses were permitted). Participants were considered relapsers when they reported less than six non-smoking days overall, or only smoking days and/or missings in week three. Participants were considered intermittent smokers when smoking and non-smoking days alternated during the diary period and the abovementioned criteria were not met.

### *Relationship satisfaction*

Both members of the couple filled in the Dutch version of the Maudsley Marital Questionnaire at baseline and follow-up (Arrindell, Boelens, & Lambert, 1983; Joseph, Alfons, & Rob, 2007). The scale consisted of ten questions regarding relationship satisfaction (ranging from 0 to 8, baseline  $\alpha = .88$ , follow-up  $\alpha = .91$ ). Relationship satisfaction in the diary period was measured by asking both members of the couples how satisfied they are with their relationship, at that moment. The scale ranged from 1 = 'Unhappy' to 10 = 'Very happy'.

### *Statistical analyses*

Intention-to-treat analyses were performed, meaning all available data was analysed (excluding outliers). Smokers who reported more than 58 daily cigarettes at baseline ( $n = 10$ ; 5 DP, 5 IP), and more than 46 cigarettes at follow-up ( $n = 3$ ; 2 DP, 1 IP) were considered outliers ( $>3$  SD above the mean) and therefore excluded. To test whether there were differences between the smokers in different intervention groups in smoking abstinence during the diary period and smoking behaviour at follow-up, a chi-square test was performed (i.e., proportion of abstainers per week and at follow-up, and smoking behaviour at follow-up). Analyses were performed for participants who were abstinent at follow-up (point prevalence, Hughes, Keely, & Naud, 2004) and for participants who remained abstinent since the intervention (prolonged abstinence, Hughes et al., 2004). Bootstrap-based (1000 samples) effect sizes and bias corrected confidence intervals were reported when possible. At follow-up, the number of cigarettes was set to zero when the participant remained quit since the intervention. Paired samples t-tests were used to test for differences in the number of cigarettes smoked and relationship satisfaction between baseline and follow-up. Linear regression was used to test for the effect of intervention on the number of cigarettes smoked at follow-up. Additionally, to control for interdependence among the couples a linear multilevel analysis was performed to test for the effect of intervention group on relationship satisfaction. The repeated covariance type used was compound symmetry heterogeneous (CSH), since this is the preferred method in dyadic models (Kenny, Kashy, & Cook, 2006).

The sum of missing diary days per individual was not related to baseline characteristics nor intervention group. However, the number of missing days was related to the



number of cigarettes smoked at follow-up ( $r = .32$ ,  $p < .001$ ). Almost all participants had (some) missing diary days, therefore up to three missings were allowed for quitters as well. Sensitivity analyses on abstinence rates were performed by assuming missing cases to be relapsers.

## Results

### *Smoking abstinence*

As reported by smokers, the point prevalence of abstinence was similar in both intervention groups,  $\chi^2(1, N = 156) = 0.14$ ,  $p = .711$ ,  $\phi = .03$ ; 95% BCa CI [-0.13, 0.20]. That is, at follow-up, 24 out of 73 (33%) participants in the dyadic group reported having quit smoking (i.e., smoking zero cigarettes). In the individual group, there were 25 out of 83 quitters (30%). When follow-up data was missing and we assumed relapse, the abstinence rates were still comparable between groups, but showed a minor decrease (24 out of 83 = 29% and 25 out of 93 = 27% respectively,  $n = 176$ ). However, this data still includes participants who relapsed once or for a short period in the past three months. When more strict rules were applied (i.e., reported no smoking since the intervention = prolonged abstinence), 14 out of 73 (19%) of the participants in the dyadic group remained successfully quit since their quit date. Of the individual group, this was 13 out of 83 (16%),  $\chi^2(1, N = 156) = 0.34$ ,  $p = .563$ ,  $\phi = .05$ ; 95% BCa CI [-0.13, 0.22]. When cases were missing and we assumed relapse, the proportion of quitters was still similar between groups, but again dropped a bit, to 14 out of 83 (17%) in the dyadic group and 13 out of 93 (14%) in the individual group. The majority of the participants who resumed smoking at follow-up did so on a daily basis (i.e., 45% in the dyadic planning group and 53% in the individual planning group), while a minority of the participants reported intermittent smoking. Overall, the smoking behaviour (e.g., non-smoking, daily smoking, intermittent smoking) at follow-up did not differ between intervention groups,  $\chi^2(4, N = 156) = 2.38$ ,  $p = .666$ ,  $\phi_c = .12$  (Table 2).

During the diary period (21 days), the dyadic group ( $n = 83$ ) did not smoke on, on average, 8.8 days, which was similar to the 8.0 days in the individual group ( $n = 92$ ),  $t(173) = -0.69$ ,  $p = .490$ ,  $MD = -0.78$ , 95% BCa CI [-3.04, 1.45],  $d = .11$ . The proportions of weekly abstainers (participants who did not smoke for either 7, 14 or 21 days in a row), did not differ between the intervention groups (Table 3). For example, in week 3 there were 4 abstainers left in the dyadic group, compared to 5 in the individual group.

### *Number of cigarettes smoked*

On average, smokers ( $n = 145$ ) reported significantly fewer cigarettes smoked at the follow-up measurement ( $M = 7.25$ ,  $SD = 7.86$ ), compared to baseline ( $M = 16.19$ ,  $SD = 8.61$ ). This difference, 8.94, 95% BCa CI [7.47, 10.49], was significant,  $t(144) = 11.56$ ,  $p < .001$ , and had a large effect size  $d = 0.96$ . When looking at relapsers only ( $n = 97$ ), that is, leaving successful quitters out of the analysis, there was still a significant decrease in number of cigarettes at follow-up ( $M = 10.84$ ,  $SD = 7.31$ ), compared to baseline ( $M = 16.18$ ,  $SD = 7.89$ ). This decrease, 5.34, BCa CI [4.04, 6.66], was

**Table 2.** Smoking behaviour at follow-up and smoking patterns in the diary as reported by smokers.

Smoking behaviour at follow-up	Dyadic Planning ( <i>n</i> = 73)	Individual planning ( <i>n</i> = 83)	Total ( <i>n</i> = 156)	Diary smoking pattern ( <i>n</i> = 142)		
				Relapse ( <i>n</i> = 74)	Intermittent ( <i>n</i> = 37)	Quitters ( <i>n</i> = 31)
'I quit smoking since the intervention'	14 (19%)	13 (16%)	27 (17%)	4 (5%)	1 (3%)	17 (55%)
'I smoked just a few cigarettes since the intervention'	12 (16%)	10 (12%)	22 (14%)	7 (10%)	5 (14%)	5 (16%)
'I started smoking daily, but quit again'	7 (10%)	11 (13%)	18 (12%)	7 (10%)	7 (19%)	4 (13%)
'I am smoking, but not daily'	7 (10%)	5 (6%)	12 (8%)	2 (3%)	8 (22%)	2 (7%)
'I am smoking daily'	33 (45%)	44 (53%)	77 (49%)	54 (73%)	16 (43%)	3 (10%)
Smoking zero cigarettes	24 (33%)	25 (30%)	49 (31%)	11 (15%)	7 (19%)	22 (71%)

significant,  $t(96) = 8.16$ ,  $p < .001$ , and had a large effect size  $d = 0.83$ . However, intervention group was no significant predictor for number of cigarettes smoked at follow-up (Table 4). During the diary weeks, smokers in the dyadic condition ( $n = 83$ ) smoked, on average, 1.8 cigarettes a day, which was not significantly different to the 2.0 cigarettes smoked in the individual planning group ( $n = 93$ ),  $t(174) = 0.72$ ,  $p = .475$ ,  $MD = 0.22$ , 95% BCa CI [-0.42, 0.83],  $d = .11$ .

### Diary smoking patterns

Smoking patterns were identified using the diary data for 142 smokers. Data on 34 participants was not analysed, because they either had no follow-up data, or too few diary days to identify a pattern. Of the 74 relapsers in the diary, 54 (73%) reported daily smoking at follow-up (Table 2). Of the 31 quitters in the diary, 22 (71%) were smoking zero cigarettes at follow-up. Intermittent smoking was displayed by 37 participants in the diary period, of which 16 (43%) smoked daily again at follow-up, 5 (14%) smoked just a few, 7 (19%) quit smoking again after a relapse, and 8 (22%) started smoking again (not daily). One participant reported having quit (i.e., not smoking since the intervention), which is invalid based on the reported smoking days in the diary. The occurrence of different smoking patterns in the diary did not differ between intervention groups,  $\chi^2(2, N = 162) = 1.12$ ,  $p = .571$ ,  $\phi_c = .08$ . Overall, these results show that for most smokers, the smoking behaviour in the first three weeks after the quit attempt gives an accurate indication of the smoking behaviour at follow-up.

### Relationship satisfaction

Table 3 shows the average daily relationship satisfaction of both intervention groups per week, which did not differ. Intervention group was not related to couples' relationship satisfaction at follow-up (Table 4). Smokers ( $n = 155$ ) reported a lower relationship satisfaction at follow-up ( $M = 6.71$ ,  $SD = 1.21$ ), compared to baseline ( $M = 6.87$ ,  $SD = 1.05$ ). Although the difference, 0.16, 95% BCa CI [0.03, 0.32], was significant,  $t(154) = 2.23$ ,  $p = .028$ , the effect size was small,  $d = 0.18$ . Partners ( $n = 161$ ) also

**Table 3.** Proportion of prolonged smoking abstinence (7, 14 and 21 subsequent days of reported not smoking) reported by smokers, and average daily relationship satisfaction per week of both members of the couples.

Smoking abstinence	Dyadic planning ( <i>n</i> = 83)	Individual planning ( <i>n</i> = 93)	Chi-Square	<i>p</i>
Week 1 (7 days)	15 (18%)	13 (14%)	0.143	.705
Week 2 (14 days)	10 (12%)	8 (9%)	0.222	.637
Week 3 (21 days)	4 (5%)	5 (5%)	Fisher's exact test	1.000

Relationship satisfaction Smokers	Dyadic planning ( <i>n</i> = 83)	Individual planning ( <i>n</i> = 92)	<i>t</i>	<i>p</i>	BCa 95% Confidence Interval of MD	
					<i>d</i>	
Week 1	8.1 (1.5)	8.2 (1.6)	0.658	.511	[−0.32 to 0.64]	0.10
Week 2*	8.4 (1.4)	8.2 (1.6)	−0.692	.490	[−0.63 to 0.29]	0.11
Week 3**	8.4 (1.4)	8.2 (1.7)	−0.637	.525	[−0.69 to 0.36]	0.11

Partners	Dyadic planning ( <i>n</i> = 82)	Individual planning ( <i>n</i> = 91)	<i>t</i>	<i>p</i>	BCa 95% Confidence Interval of MD	
					<i>d</i>	
Week 1	8.4 (1.4)	8.4 (1.3)	0.099	.921	[−0.37 to 0.36]	0.02
Week 2*	8.5 (1.3)	8.4 (1.3)	−0.505	.614	[−0.49 to 0.29]	0.08
Week 3**	8.5 (1.4)	8.3 (1.4)	−0.677	.500	[−0.63 to 0.30]	0.11

Note. Strict rules are applied for smoking: no relapses or missings are allowed. \*DP: 72 smokers, 73 partners, IP: 83 smokers, 83 partners, \*\*DP: 68 smokers, 68 partners, IP: 80 smokers, 78 partners. Standard deviations of relationship satisfaction are in brackets.

reported a lower relationship at follow-up ( $M = 6.58$ ,  $SD = 1.30$ ), compared to baseline ( $M = 6.85$ ,  $SD = 1.05$ ). This difference of 0.27, 95% BCa CI [0.12, 0.43], was significant,  $t(160) = 3.52$ ,  $p = .001$ , but also had a small effect size,  $d = 0.28$ . Partners reported a slightly lower relationship satisfaction, compared to their smoking partners (Table 4).

## Discussion

The aim of this RCT was to examine whether involving a non-smoking partner could improve the effectiveness of a planning intervention to quit smoking. Of all participants, 31% had quit smoking at follow-up (point prevalence). Given previously reported effectiveness of implementation intentions for quitting smoking (15.48%: Armitage, 2016), this number exceeded our expectations. The number of cigarettes smoked per day dropped significantly by more than 50%; even the group of relapsers showed a decrease (of 33%). This confirms the idea that the use of implementation intentions results in a decrease in number of cigarettes smoked (Armitage, 2008, 2016). Unexpectedly, both intervention groups showed similar results; involving the non-smoking partner in the intervention did not increase its effectiveness. For most participants, the smoking pattern shown in the diary seemed to be indicative of smoking behaviour at follow-up, but patterns also did not differ between intervention groups. The couples' relationship satisfaction was similar in both intervention groups, but showed a minor decrease (small effect) over time for both members of the couples.

**Table 4.** Bootstrap regression model of number of cigarettes at follow-up ( $n = 144$  smokers) and multilevel model of relationship satisfaction at follow-up ( $n = 167$  subjects).

Number of cigarettes*					
Predictors	Estimate	Bias	SE	$p$	BCa 95% Confidence Interval
Constant	-0.63	0.06	2.42	.805	[-5.49 to 4.33]
Nr of cigarettes baseline	0.34	-8.37E - 5	0.11	.002	[0.16 to 0.56]
Intervention**	1.62	-0.04	1.29	.206	[-0.94 to 3.95]
Relationship satisfaction					
Predictors	Estimate	SE	$t$	$p$	95% Confidence Interval
Intercept	1.89	0.55	3.42	.001	[0.80 to 2.99]
Relationship satisfaction baseline	0.80	0.05	15.49	.000	[0.70 to 0.90]
Intervention**	-0.36	0.28	-1.30	.197	[-0.91 to 0.19]
Role***	-0.55	0.27	-2.04	.043	[-1.09 to -0.02]
Intervention*Role	0.29	0.18	1.65	.101	[-0.06 to 0.64]

Note. \* $R^2 = 0.14$ ,  $F(2,142) = 11.83$ ,  $p < .001$ . \*\*Individual group = 1, Dyadic group = 2. \*\*\*1 = Smoker, 2 = Partner.

### Effect of dyadic planning compared to individual planning

Contrary to our expectations, the dyadic planning group was not more successful than the individual planning group either in quitting smoking or in decreasing the number of cigarettes smoked. The reason for this is not clear but it may be related to the type of behaviour the planning focused on. Previously published studies on the effect of dyadic planning did not report consistent results, and merely focused on implementing a new behaviour (Burkert et al., 2011; Keller et al., 2015; Knoll et al., 2017). To implement a new behaviour into daily routines is likely to be different than quitting an addiction. Even though a non-smoking partner is a valuable support provider in various aspects of life including trying to quit smoking (Scholz et al., 2016), involving the partner in the intervention by also working on formulating if-then plans apparently was not enough to increase effectiveness.

Another explanation might be that we may have recruited couples in which partner involvement and support was already high. Previous research has shown that happier couples are more likely to participate in research together (Hagedoorn et al., 2015). We invited both partners explicitly, so all couples were motivated to enter this intervention together. Also, couples who were highly involved in each other's lives, but were randomized into the individual planning condition, might have discussed the planning afterwards, creating more partner involvement and collaboration. In other words, a minimal intervention like dyadic planning may not have been sufficient to increase an already high involvement of partners.

A sample of happy and involved couples might also explain why there was no difference in relationship satisfaction between the two intervention groups. We expected to find a higher relationship satisfaction in the dyadic planning group, because of a potential buffering effect (Burkert et al., 2011). Dyadic planning could act as a buffer for the effects of partners' negative control over behaviour change. Possibly, the frequency of negative behaviours was low in both intervention groups. This could explain why both intervention groups showed only a small decline in their relationship satisfaction: quitting smoking can be a stressful period resulting in elevated irritability in smokers (Hughes, 2007). Examining the diary data further may give more insight into the role of partner behaviours during a quit attempt and whether they differ between the intervention groups.

This RCT lacked a true control group (i.e., no intervention). However, since implementation intentions have been proven effective in quitting smoking (Armitage, 2008, 2016), we considered the individual planning a valid control group to test for the effectiveness of a dyadic planning intervention. Additionally, the involvement of a non-smoking partner is only purposeful when it increases the effectiveness of an individual planning.

### ***Defining and assessing smoking abstinence***

With the diary data, we could recognize smoking patterns in the participants. These smoking patterns were related to abstinence at follow-up. This shows that the first few weeks after a quit attempt could be indicative of the chance of success in the longer term. This is in line with earlier findings pointed out in a review: most relapse occurs in the first eight days (Hughes et al., 2004). This raises an opportunity to possibly incorporate daily diaries or smartphone feedback messages to quitters and their spouses to work with the intention plans and stick to not smoking.

Furthermore, the diary data allowed us to check the self-reported smoking behaviour at follow-up. It appeared that most of the self-reported prolonged abstainers had reported smoking in some diary days or had one or more missing diary days. This explains the relatively small percentage of abstainers in the diary period: most participants had missing days and did therefore not meet our definition of a consecutive period of non-smoking. The difference in percentages between prolonged abstinence and point prevalence shows that the effectiveness of the intervention was greatly determined by the definitions we use for quitters. When relapses and missings are permitted and effectiveness is solely based on looking at the number of cigarettes at follow-up (i.e., point prevalence), the effectiveness is greater. Given the difficulty of quitting smoking and that renewed quitting after relapse is common (Bold et al., 2005), looking at point prevalence might be more accurate. Future research should be attentive to this difference when interpreting and reporting smoking abstinence outcomes. In addition, a physiological nicotine test could increase the reliability of the self-reported smoking status at follow-up, although self-reports of smoking are accurate in most studies (Patrick et al., 1994).

Dealing with missing data in diary studies has received little attention in current research. Missing data leads to difficulties in analysis and interpretation of the data, even though our completion rate of 76% is quite good for a three-week diary period. Although self-reports of smoking are accurate in most studies (Patrick et al., 1994), participants might be more likely to skip a diary on days that they smoked. That is, smoking might feel like a failure, resulting in avoiding reporting it.

In addition to possible underlying smoking behaviour, missing diary days could raise another issue. The finding that participants with more missing days were likely to report smoking more cigarettes at follow-up could mean that relapsers are less likely to continue filling in the diary, but also that keeping the diary might assist in an intervention on its own. Therefore, successful quitting and the reduction in smoking may be partly caused by participating in a diary study (reactivity; Bolger & Laurenceau, 2013), although validation of this effect remains inconclusive (Iida, Shrout, Laurenceau, & Bolger, 2012).

To conclude, this planning intervention resulted in a higher percentage of quitters than reported in literature, which could have two explanations. First, the current study focussed on single-smoking couples instead of individual smokers. Participants sign up and participate as a couple, which might have been enough to increase partner involvement and therefore the intervention's effectiveness. The involvement of the non-smoking partner in the study, therefore, did have some beneficial effect on quitting smoking. Future research could focus on the mechanisms behind this partner involvement to give more insight into the role of partner behaviours during a quit attempt. Second, participating in a diary can cause reactivity (Bolger & Laurenceau, 2013) which might have increased the effectiveness of the intervention.

## Conclusion

Implementation intentions are a helpful tool in helping smokers to quit smoking, or decrease their numbers of cigarettes smoked. The planning intervention in this RCT showed that, over time, 31% participants quit smoking, and the number of cigarettes was reduced by more than 50%. However, the dyadic planning condition, in which the non-smoking partner helped creating the plan, was not more effective, nor did these participants report a higher relationship satisfaction. Nevertheless, both planning interventions resulted in a higher percentage of quitters than reported in the literature. This may be because we recruited relatively highly motivated smokers with highly involved partners or because completing a diary increased the effect of the intervention. Taken together, our findings do not support strong recommendations to involve non-smoking partners in a planning intervention itself, nonetheless couple participation and daily measurements could be important components of future interventions. Further examination of the diary data may reveal more insight in social processes that play a role in a quit attempt, and that may be incorporated in a dyadic intervention.

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No potential conflict of interest was reported by the authors.

## Data availability statement

The data that support the findings of this study are available from the corresponding author, Anne Buitenhuis, upon reasonable request.

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