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How eating-related social media postings influence healthy eating in senders and network members: Two field experiments with intensive longitudinal data☆

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Abstract:

Young adults are frequently confronted with eating-related social media content. How such exposure influences eating in those who post and their network members is largely unknown. We conducted two intensive longitudinal field experiments combining self-reports with social media data. The posting behavior of young adults was manipulated. We examined how postings about fruit and vegetables affected intake in senders and their network members (Study 1, N = 81) and in senders with a change goal (Study 2, N = 128). Potential mechanisms of action were explored. Descriptively, posting led to a stronger increase of senders' and network members' intake, but this increase was not statistically significant. Posting led to higher perceived social support and injunctive norms of senders (Study 1). Posting supported eating behavior change; the effect size was comparable to picture-based self-monitoring of intake (Study 2). Intraindividual variations in senders' daily eating-related social media activities were associated with daily eating behavior and perceived social support (both studies), daily self-efficacy, experiential and instrumental attitudes, and goal commitment (Study 2). Our studies underline that social media environments should be considered in research and interventions targeting eating behavior of young adults.

1. Introduction

Social media is very popular, especially among adolescents and young adults (Pew Research Center, 2021). One topic of particular interest is communication about food (e.g., Hu et al., 2014). Young adults are frequently exposed to both healthy and unhealthy eating content and likely influenced by both real-world peers and social media influencers (Friedman et al., 2022). Given that adolescents and young adults also frequently do not meet dietary recommendations, such as eating five portions of fruit and vegetables per day (e.g., Mensink et al., 2013), social media are ideal platforms for promoting and supporting healthy eating among this age group.[1]

Social media is typically used to deliver intervention materials (e.g., informational or educational content) or as an add-on in multicomponent interventions (e.g., interventions that focus on face-to-face meetings and offer access to a group chat on social media; cf. Petkovic et al., 2021). Thus, the potential of social media itself (i.e., already existing networks that can provide social support; special interest groups that were formed outside of a research project) may still be underused for health promotion. Importantly, interventions in such "natural" social media settings could facilitate effects on individuals who are actively posting and spillover effects to their social network (Valkenburg, 2017).

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[1] Abbreviations: B&M = books and movies; CGM = centered around the grand mean; CWC = centered within clusters; EMA = ecological momentary assessment; FVI = fruit and vegetable intake.

For example, intervention effects may scale when a social media poster ("sender") influences which postings other individuals ("network members") view or respond to. How social media uniquely affects senders and network members has been rarely researched, especially in the context of eating behaviors (see, e.g., Hawks et al., 2020; Petkovic et al., 2021, for reviews). Potential underlying mechanisms have been largely ignored. To date, most of the research is cross-sectional or conducted in a laboratory and, thus, does not allow conclusions about causality or lacks external validity (Sina et al., 2022). It remains unclear whether publicly posting about one's own eating behavior in one's own social media network benefits both, senders and receivers of these postings (Chung et al., 2017; Klassen et al., 2018).

1.1. Aims of the current experimental studies

The goals of the current experimental studies were to examine the effects of healthy eating-related postings on healthy eating behavior in senders and network members, and to identify potential underlying psychosocial mechanisms. As an indicator of healthy eating behavior, we examine fruit and vegetable intake and intake-related social media postings because (a) the exact composition of a healthy diet is still somewhat debated but it is uncontroversial that a high intake of fruits and vegetables is healthy (de Ridder et al., 2017; GBD 2017 Diet Collaborators, 2019), and (b) indicators of healthy diets usually cluster, for example, people with a high fruit and vegetable intake often also eat wholegrain products (e.g., Maghsoudi et al., 2016). The two studies extend existing research in several ways: First, they measure the unique effects of social media postings on eating behavior. Second, their experimental design allowed examining causal effects of social media on eating. Third, they explicitly tested theoretically derived mechanisms potentially underlying the relation between healthy eating-related social media postings and healthy eating behavior. Fourth, the studies are the first to provide insights into the temporal relations and dose-response relationships of intraindividual day-to-day variations in healthy eating-related social media use and healthy eating behavior.

2. Study 1: Effects of posting about fruit and vegetables on intake

2.1. Theoretical background: Social media use, perceived social support, and social norms

Social media use may increase *social support* (Simeon et al., 2020), an interindividual resource assisting successful goal-striving (Fitzsimons & Finkel, 2010), and thereby facilitate healthy eating (e.g., Scholz et al., 2013). It can be provided through affirmative social responses to postings (e.g., likes, supportive comments) or directly addressing network members' instrumental and emotional needs, for example by providing healthy recipes or empathetic texts (de la Peña & Quintanilla, 2015; Simeon et al., 2020). Research also shows that participation in computer-mediated support groups, where active and passive activities are closely intertwined, increases social support (Yang, 2020).

Others' healthy and unhealthy eating styles may also change *social norms* and motivate people to adjust their eating accordingly (e.g., Giese et al., 2015). In social media, food postings and related discussions may update perceived descriptive eating norms of both senders and network members by displaying the actual eating behavior in the group (Higgs & Thomas, 2016). In addition, receiving likes and affirming comments further convey social approval of the depicted eating behavior (de la Peña & Quintanilla, 2015; Hawkins et al., 2021), and thus influence perceived injunctive eating norms (Higgs & Thomas, 2016) and the social image of healthy and unhealthy foods (e.g., König et al., 2017¨).

2.2. Hypotheses

We expected (H1) that posting about one's fruit and vegetable intake (FVI) on social media would lead to a stronger increase in senders' FVI compared to posting about a control topic; (H2) that network members whose study partner ("sender") post about FVI would show a stronger increase of FVI compared to network members whose study partner post about a control topic; (H3) stronger increases of the following psychosocial outcomes for senders who post about FVI (compared to about the control topic) and their network members: (a) perceived FVI-related social support, (b) perceived injunctive, and (c) descriptive FVI norms; (H4) that the effects in H1 and H2 would be at least partially mediated via increased (a) perceived FVI-related social support, (b) perceived injunctive FVI norms, and (c) descriptive FVI norms; and (H5) positive dose–response relationships between daily FVI-related social media activities and (a) daily FVI and (b) daily FVI-related social support in senders and network members. Appendix A contains a graphical overview of the hypotheses of Study 1 and 2.

2.3. Method

2.3.1. Design and procedure

We conducted a field experiment with baseline and follow-up assessment, ecological momentary assessment (EMA; Shiffman et al., 2008) over 7 days, and coding of public online postings. Young adults (18–29 years) participated as dyads with one sender (i.e., the person that would receive an intervention) and one network member (i.e., a Facebook friend of their choice). Senders were randomized into one of two posting conditions: online posting about their FVI (intervention condition) or online posting about their favorite books and movies/series (B&M; control condition). Postings in both conditions had to be made on Facebook. The resulting design is a 2 (posting: online posting about FVI vs. B&M) × 2 (time: baseline vs. follow-up) mixed design with additional daily experience sampling data (Fig. 1). Participants were recruited via the study management systems of the University of Konstanz and the University of Mannheim, word of mouth recommendations, and flyers on the campus. Participants received money or a combination of money and course credit as compensation, dependent on the number of daily social media postings and completed questionnaires: All senders were incentivized to post status updates consistent with their experimental condition (FVI vs. B&M) on their personal Facebook wall, and all network members were incentivized to react and comment on these postings (see Appendix B). To rule out that the effect of posting could be merely explained by differences in self-monitoring of FVI, we asked senders in the B&M condition to track at least one fruit and vegetable serving per day by uploading photos and short notes via the movisensXS app. An overview of all suggested behavior change techniques (BCTTv1; Michie et al., 2013) in the different experimental condition is provided in Appendix C.

The study was approved by the Institutional Review Board of the University of Mannheim and preregistered via the Open Science Framework (https://osf.io/5h2vu/). Importantly, a second between- subject manipulation was not reliably delivered due to technical difficulties. Therefore, we could not follow the preregistration protocol and had to exclude participants receiving the defective manipulation. The conducted analyses are matched to the preregistered analyses of Study 2, and the results should thus be considered as exploratory.

At baseline, participants self-selected their role within the dyad (sender or network member) and provided informed consent. Senders were then randomized to their experimental posting condition and completed the questionnaires. During the intervention period (7 days), participants were invited to up to 8 daily surveys. Data were collected with Unipark (Questback GmbH, Cologne, Germany) and movisensXS, version 1.3 (movisens GmbH, Karlsruhe, Germany), which was used to trigger and administer the daily surveys.

2.3.2. Participants

Of the 96 initial participants (48 dyads), 41 senders and 40 network members provided sufficient data for analysis (Appendix D for

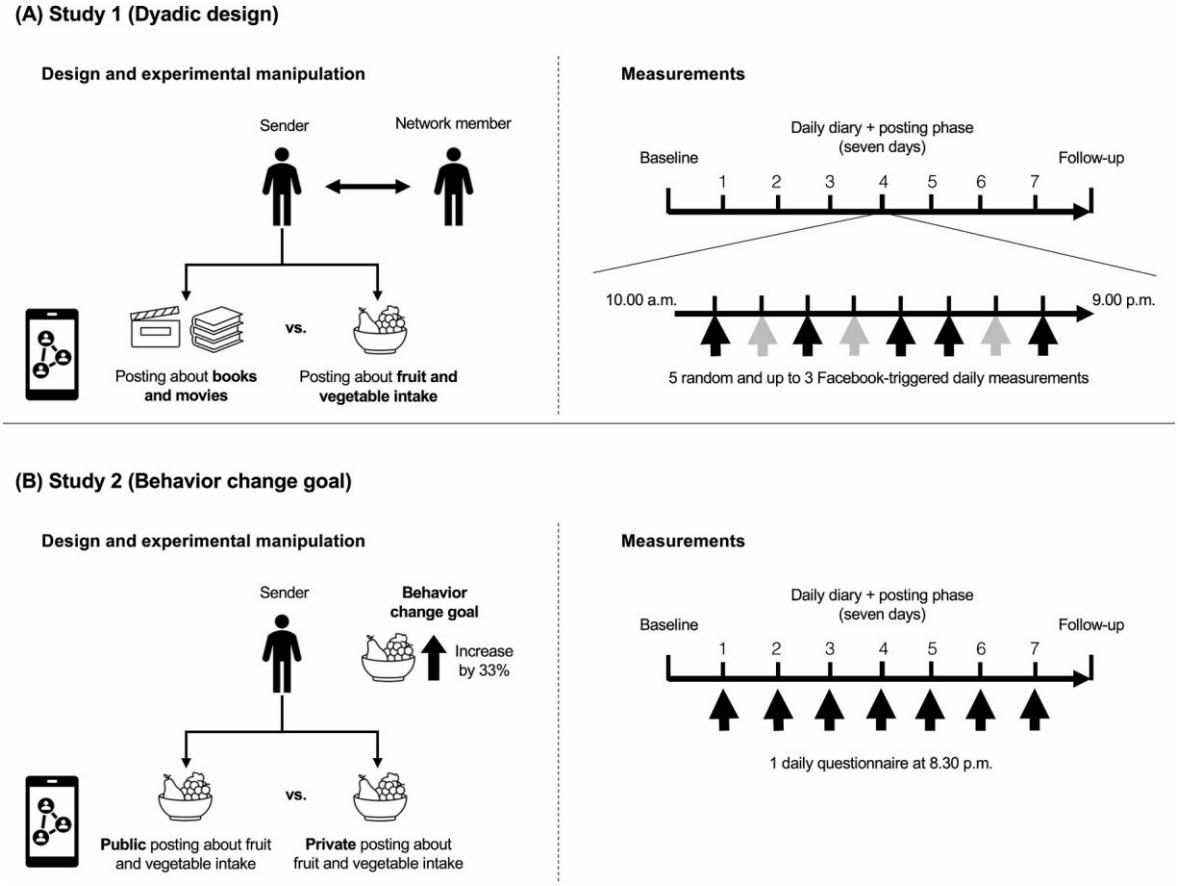

Fig. 1. Study designs of Study 1 and 2.
Note. (A) In Study 1, participants were recruited as dyads, which comprised one sender (i.e., the person that received an intervention and posted) and one Facebook network member of their choice. Senders' online posting on Facebook was experimentally manipulated. Five daily surveys were randomly triggered (in 90-min time windows between 10:00 a.m. and 9:00 p.m.). Up to three additional surveys were triggered by participants' Facebook use (after using Facebook, participants were invited to a survey). After a survey was triggered, the Facebook trigger was inactivated for 2 h to avoid triggering multiple surveys within a short time frame. (B) In Study 2, only senders were recruited and received a goal to increase their fruit and vegetable intake. Their online posting mode was experimentally manipulated (public posting on Instagram vs. private posting in WhatsApp chat). Senders answered one questionnaire per day.

participant flow chart). The final sample did not differ from the initial sample, except that excluded senders reported lower FVI at baseline, t (33.37) = 4.82, p < .001, d = 1.21, and excluded network members reported higher autonomous motivation for eating fruit and vegetables, t (10.06) = -2.84, p = .017, d = -1.05 (Appendix E for baseline characteristics).

2.3.3. Materials

2.3.3.1. Facebook data. Every Facebook posting of senders during the intervention week was saved and coded by one rater regarding the day and content of postings (posting about B&M: yes/no; posting about FVI: yes/no). About half of the postings (46%) were coded by two independent raters. Intercoder agreement was high (Krippendorff's α: 0.815 for B&M; 0.821 for FVI content).

2.3.3.2. Baseline and follow-up assessment. FVI in the last week was measured using four items adapted from the German Health Examination Survey's food frequency questionnaire (Haftenberger et al., 2010), for example: "How often did you eat fruit (e.g., apple, banana, or canned fruit)?", and "When you eat fruit, how much do you usually eat?". Average daily number of portions was calculated according to the adapted scoring scheme (Haftenberger et al., 2010). *Perceived FVI-related social* support from the study partner (network member) and the sender's Facebook network was measured with the Frequency subscale of the Child and Adolescent Social Support Scale for Healthy Behaviors (CASSS-HB; Menon & Demaray, 2013), adapted to eating fruit and vegetables (Cronbach's α study partner: 0.92; Facebook network: 0.89). The two scores were averaged to one overall perceived FVI-related social support score. *Perceived norms regarding FVI* of the study partner and the Facebook network (perceived descriptive FVI norms) were measured with 12 items for each reference group (see Cullen et al., 2001). The items were adapted to the study partner and Facebook network (e.g., "most of my friends on Facebook eat vegetables at lunch"; Cronbach's α study partner: 0.85; Facebook network: 0.87). The perceived descriptive norm items were averaged for each referent group (study partner and Facebook network). These scale means were then averaged into one overall perceived descriptive norm score. Perceived injunctive FVI norms were assessed with six items (from Di Noia & Cullen, 2015) adapted to the study partner and Facebook network (e.g., "My social network on Facebook thinks that eating vegetables at lunch is a good thing to do") and four additional self-generated items to capture FVI more generally (e.g., "My social network on Facebook thinks that eating it is important to eat fruits or vegetables at the three main meals"; Cronbach's α study partner: 0.89, Facebook network: 0.92). The calculation of the overall perceived injunctive norms score was analogous to the perceived descriptive norms score.

Control variables were measured at baseline. *Education level* was assessed by asking about highest educational degree completed and coding according to the International Standard Classification of Education (ISCED) into the categories low (ISCED 0–2), medium (ISCED 3–4),

and high (ISCED 5–8). *Age*, *weight*, and *height* were assessed with open-ended questions. *General Facebook usage frequency* was measured asking how often participants used Facebook (participants chose the unit that best fit their usage pattern, i.e., how many times a week, day, or hour they used Facebook).

2.3.3.3. Daily measures. Daily study-related Facebook usage was measured with two items for active and passive usage intensity (adapted from Verduyn et al., 2015), for example "How often/intensely did you actively use Facebook since the last survey for content relating to posts you made as part of the study?" with detailed descriptions of active and passive use. The two items were averaged. *Daily FVI was assessed with two items,* e.g., "How many portions of fruit did you eat since the last survey?". There was a strong correlation, $r = 0.70$, $t(38) = 6.11$, $p < .001$, between reported FVI in the intervention week assessed via follow-up questionnaire and the average of daily assessments. *Daily perceived FVI-related social* support was measured with four adapted items from the baseline questionnaire. Participants rated statements such as "Since the last survey, my study partner/my social network on Facebook … encouraged me to eat more fruit and vegetables." The ratings for study partner and Facebook network were averaged into one score.

2.3.4. Statistical analysis

All analyses were performed separately for senders and network members using R version 4.1.2. For the dose–response analyses, all participants who provided follow-up data and a minimum of 2 days with at least 50% of possible surveys answered (i.e., four surveys) were included in the analyses. The same participants were included in the group/between-level analyses. Internal consistencies for daily measures were calculated using nested alpha (Nezlek, 2017). The sample size of the different posting conditions was as intended (20 participants per condition); however, the participant loss also led to a loss of statistical power (post-hoc power calculations indicate a power of 0.88 for detecting medium and 0.56 for detecting small to medium interaction effects, respectively). Because of the lower statistical power, we also report findings with p values < .100 in Study 1 as relevant to future studies.

2.3.4.1. Analyses of intervention effectiveness. We fitted mixed 2 (posting: about FVI vs. about B&M) × 2 (time: baseline vs. follow-up) ANOVAs on FVI, perceived FVI-related social support, and perceived descriptive and injunctive FVI norms with the R package afex. Follow-up tests were conducted with *t*-tests and Holm *p*-value adjustment

The R package lavaan version 0.6–3 was used to analyze mediation effects for senders and network members on the group level (i.e., the expected indirect effects). We fitted three path models with the posting condition as independent variable (dummy coded), the standardized change in FVI from baseline to follow-up, and the standardized change values of each mediator variable from baseline to follow-up. Parameters, standard errors, and confidence intervals for total and indirect effects of posting condition on FVI were estimated using bootstrapping (percentile method) with 10,000 iterations.

2.3.4.2. Analyses of dose–response relationships. To test for dose- response relationships for FVI and perceived social support of both senders and network members on a daily level, data were aggregated by calculating the daily means and the total portions of fruits and vegetables per day. In four multilevel models, we predicted for senders and network members separately, a) the daily FVI of senders and network members in zero-inflated negative-binomial multilevel models (Gelman & Hill, 2006) with the R packages glmmADMB and lmerTest, and b) perceived social support in multilevel regression models. The predictors "daily number of senders' FVI-related postings" and "senders' study-related Facebook usage" were centered around the person mean, continuous control variables at the person level (BMI, age, general Facebook usage frequency) were grand mean centered (Enders & Tofighi, 2007). Categorical control variables (sex, education level) were effect coded. In addition, we controlled for assessment day and random person-level intercepts. We standardized the regression coefficients of continuous variables in the dose–response analyses with the R package parameters.

2.4. Results

2.4.1. Manipulation check for the posting manipulation

Senders in the FVI condition ($M = 10.25$, $SD = 4.19$) posted more postings about FVI than those in the B&M condition ($M = 0.67$, $SD = 2.46$), $t(30.38) = -8.88$, $p < .001$, $d = -2.79$, and vice versa (B&M condition B&M postings: $M = 12.86$, $SD = 8.78$; FVI condition: $M = 0.00$, $SD = 0.00$; $t(20) = 6.71$, $p < .001$, $d = 2.07$). Importantly, senders in the B&M condition ($M = 11.86$, $SD = 6.56$) tracked a similar number of total FVI pictures during the intervention week (via Facebook postings and the movisensXS app) as senders in the FVI condition ($M = 10.25$, $SD = 4.19$), $t(34.21) = 0.94$, $p = .354$.

2.4.2. Group-level effects of posting

2.4.2.1. Effects of posting on senders' FVI and psychosocial outcomes. Posting about one's FVI on social media did not significantly increase FVI more strongly than posting about B&M (see Table 1 and Fig. 2; not confirming H1). However, the trajectories of FVI over time were different between the conditions: Follow-up tests showed a decreasing trend of FVI in senders who posted about B&M ($p_{adj} = .090$) but not in those who posted about FVI (see Table 1 and Fig. 2), indicating that there could be systematic differences in a higher-powered sample.

In contrast, perceived FVI-related social support increased over time, and this increase differed between the two experimental conditions (i.e., significant Posting × Time effect; Table 1 and Fig. 2). In line with H3a, follow-up tests showed that only participants posting about FVI reported an increase in perceived FVI-related social support ($p_{adj} = .052$), but participants posting about B&M reported a decrease ($p_{adj} = .099$). The same interaction and time trends were found for perceived injunctive norms (H3b) but not for perceived descriptive norms (H3c): Only participants posting about FVI reported an increase in perceived injunctive FVI norms ($p_{adj} = .027$; Table 1).

In the mediation analyses, posting about FVI (compared to posting about B&M) did not significantly indirectly predict the change of senders' FVI via increases in FVI-related social support, perceived injunctive or descriptive FVI norms (see Appendix F). Thus, we did not find support for the expected mediation effects (H4a-c) in senders.

2.4.2.2. Effects of posting on network members' FVI and psychosocial outcomes. Network members whose study partner ("sender") posted about FVI showed no significantly stronger FVI increase compared to network members whose study partner posted about B&M (Posting × Time; Table 1 and Fig. 1; H2). However, post-hoc tests revealed a marginally significant increase of FVI in network members whose study partner posted about FVI ($p_{adj} = .087$) but not in those whose study partner posted about B&M (see Table 1 and Fig. 2), again indicating that H2 effects may not have been statistically significant due to a lack of power.

In addition, we did not find the expected significant stronger increase of perceived social support and norm perceptions in network members whose study partner posted about FVI and thus no evidence for H3a-c (see Table 1 and Fig. 2). Yet, network members of study partners who posted about FVI generally reported higher perceived social support and more FVI-friendly injunctive norms independent of questionnaire timing (effect of Posting; Table 1).

The mediation analyses showed that posting about FVI (compared to B&M) did not significantly indirectly predict the change of network

Table 1
Mean changes from baseline to follow-up of outcomes for the B&M and FVI posting conditions in both senders and network members (Study 1).

Outcome variable	Baseline - follow-up (Δ)		Posting × Time interaction effect			Posting main effect			Time main effect		
	M (SE)										
	B&M	FVI	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Senders	*n* = 21	*n* = 20									
FVI	− 1.27 (0.60) †	− 0.29 (0.74)	1.07	.307	.03	1.47	.233	.04	2.74	.106	.07
Perceived FVI-related social support	− 3.30 (1.91) †	4.59 (1.90) †	8.56	.006*	.18	0.18	.675	.01	0.23	.637	.01
Descriptive FVI norms	0.01 (0.06)	0.19 (0.10)	2.31	.136	.06	0.75	.391	.02	2.73	.106	.07
Injunctive FVI norms	0.14 (0.13)	0.61 (0.22)*	3.40	.073†	.08	6.07	.018*	.14	8.76	.005*	.18
Network members	*n* = 20	*n* = 20									
FVI	− 0.34 (0.72)	1.00 (0.46) †	2.44	.126	.06	0.19	.663	.01	0.59	.447	.02
Perceived FVI-related social support	− 2.52 (1.80)	1.44 (1.89)	2.29	.138	.06	4.42	.042*	.10	0.17	.681	.00
Descriptive FVI norms	0.07 (0.08)	0.04 (0.05)	0.12	.731	.00	1.46	.234	.04	1.27	.267	.03
Injunctive FVI norms	0.21 (0.22)	− 0.03 (0.14)	0.87	.356	.02	3.15	.084†	.08	0.47	.498	.01

Note. *F*, *p*, and η_p^2 are derived from repeated measures analyses of variance. The significance level of the change scores shows the *p*-value from holm-corrected follow-up paired sample *t*-tests. B&M = books and movies. FVI = fruit and vegetable intake. †$p < .100$. *$p < .050$.

members' FVI via increases in FVI-related social support, perceived injunctive, or descriptive FVI norms (Appendix F). Thus, the hypothesized mediation effects (H4a-c) in network members could not be confirmed.

2.4.3. Dose-response relationships between daily FVI-related social media activities and daily FVI and FVI-related social support

We included 127 days of 20 senders and 122 days of 19 network members from the FVI posting conditions to examine dose–response relationships (Tables G1 and G2). As expected, we found positive dose- response relationships between senders' daily study-related Facebook usage and daily FVI (β = 0.16, *p* = .059) and perceived FVI-related social support (β = 0.17, *p* = .002). That is, on days where senders used Facebook more than usual (compared to their personal mean), they reported higher FVI and perceived FVI-related social support. We did not find such relationships for the number of senders' daily FVI-related postings (see Table G1 and Fig. 3). Thus, H5a and H5b were partially supported for senders.

We found positive dose-response relationships between network members' study-related Facebook usage and daily perceived FVI-related social support (β = 0.08, *p* = .007) but not daily FVI (β = 0.04, *p* = .449). That is, on days on which network members used Facebook more than usual, they reported higher perceived FVI-related social support. On days with more FVI-related postings by senders, network members did not significantly report higher FVI or FVI-related social support (Table G2; Fig. 3). Thus, H5a was not supported, H5b partially for network members.

2.5. Discussion

While Study 1 indicated that posting about FVI could positively affect FVI, perceived social support, and injunctive norms, particularly in senders of the postings, the sizes of these effects may be a bit smaller than expected and therefore could not be reliably evoked with the given sample size. The smaller impact of FVI postings could also be explained by the absence of a concrete behavior change goal (e.g., Inauen et al., 2017). Moreover, the results illustrate that more experiments are warranted to improve our understanding of how FVI postings relate to FVI-related psychosocial factors. We addressed these issues in Study 2 by increasing the sample size, adding a goal-setting intervention, and examining additional psychosocial mechanisms that may mediate a posting-FVI relationship. We also simplified the recruitment and only included senders of postings.

3. Study 2: How public self-monitoring via social media affects FVI change

3.1. Theoretical background: Social media use and related psychosocial mechanisms

Important psychosocial mechanisms for behavior change that have not been researched in Study 1 or other previous studies on healthy eating behavior change in social media include: self-efficacy, attitudes, and goal commitment. We define these constructs and explain their importance for the current research in the following: *Self-efficacy* is the belief about one's capability to perform a specific behavior even when facing barriers and obstacles (Bandura, 1997). Dietary self-efficacy can be increased by self-monitoring personal nutrition successes via social media postings (Prestwich et al., 2014) or receiving positive reinforcement through likes and comments (Bandura, 1997; de la Peña & Quintanilla, 2015; Prestwich et al., 2014; Yang, 2020). Likewise, postings about FVI may affect senders' perception of favorability of FVI, that is, their *attitudes*, via self-persuasion and self-concept changes (Valkenburg, 2017). Even the mere exposure to food (pictures) via postings could influence attitudes (Mata et al., 2018). Increases in self-efficacy and favorableness of attitudes evoke health behavior change (Sheeran et al., 2016). Finally, postings could also increase *FVI-related goal commitment*. Goal commitment has been defined as the "volitional psychological bond reflecting dedication to, and responsibility for […]" a behavior (Klein & Cooper, 2013, p. 67). Senders' commitment regarding their FVI goals could increase through heightened publicness of goals, received or anticipated social feedback, and external monitoring (Klein et al., 1999; Valkenburg, 2017), eventually leading to higher goal attainment (Klein et al., 1999).

3.2. Hypotheses

We expected (H1) that public posting about one's FVI on social media would be more effective in increasing senders' (a) FVI and (b) FVI intentions compared to private "posting" of FVI (private picture-based self-monitoring of FVI); (H2) stronger increases of the following psychosocial outcomes for senders who publicly (compared to privately) post about FVI: (a) perceived FVI-related social support, (b) perceived descriptive and (c) injunctive FVI norms, (d) FVI-related self-efficacy, (e) experiential and (f) instrumental FVI attitudes, and (g) goal commitment; (H3) that the effects in H1a and H1b would be at least partially mediated via the psychosocial outcomes (a) to (g) described in H2; (H4) there would be positive dose–response relationships between daily FVI-related social media activities and (H4.1a) daily FVI, (H4.1b) FVI intentions, and (H4.2) the psychosocial outcomes (a) to (g) described in H2. See also Appendix A for a graphical presentation of the hypotheses.

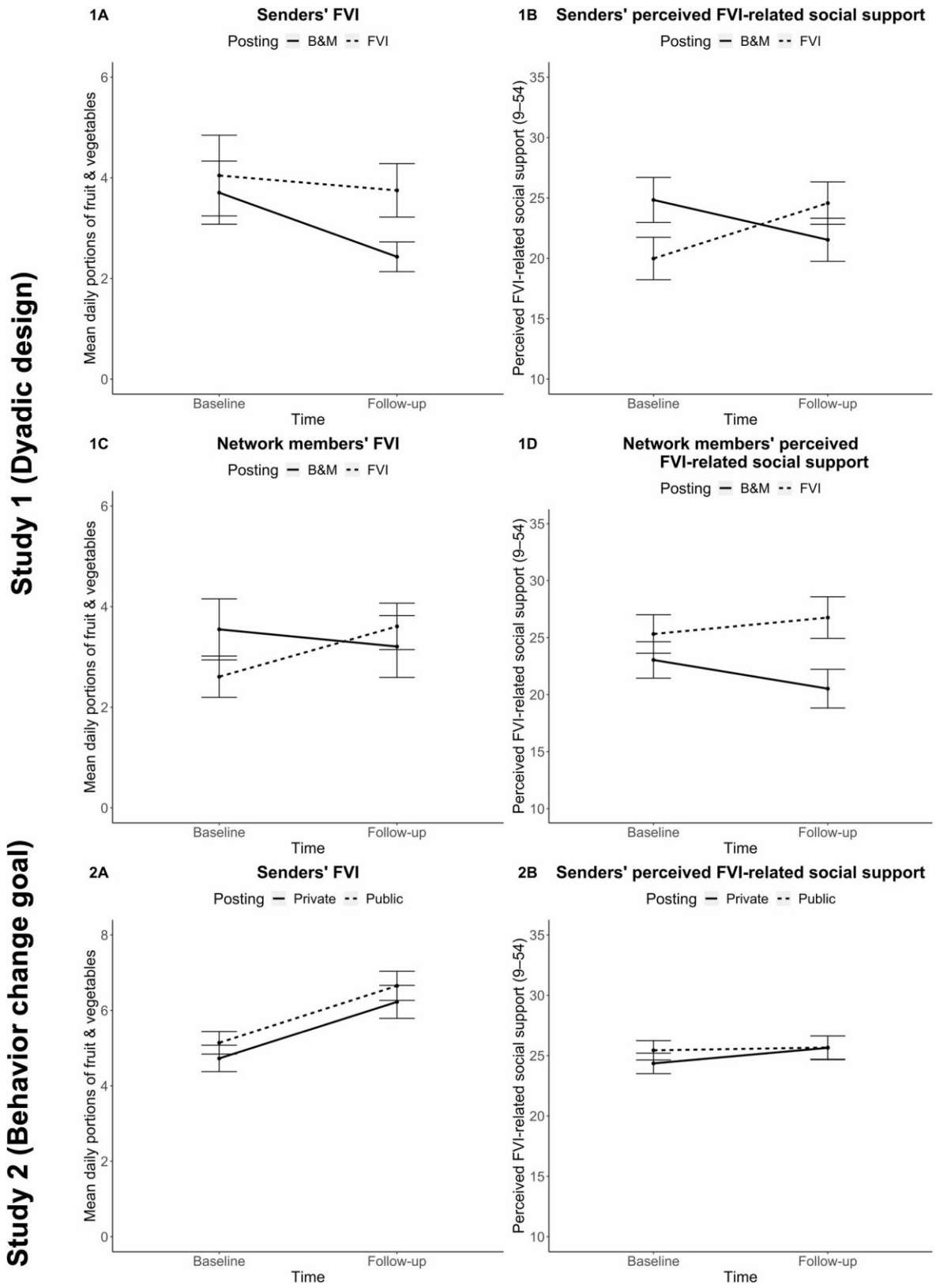

Fig. 2. Group-level effects of posting about fruit and vegetable intake (FVI) on FVI and perceived FVI-related social support of senders (Studies 1 and 2) and network members (Study 1).
Note. Study 1 had a dyadic design (sender + Facebook network member) without an additional behavior change goal for senders. In Study 2, senders participated alone but received a behavior change goal. Error bars represent the standard error of the means. Values in parentheses on the *y* axis show theoretical scale minima and maxima. FVI = fruit and vegetable intake.

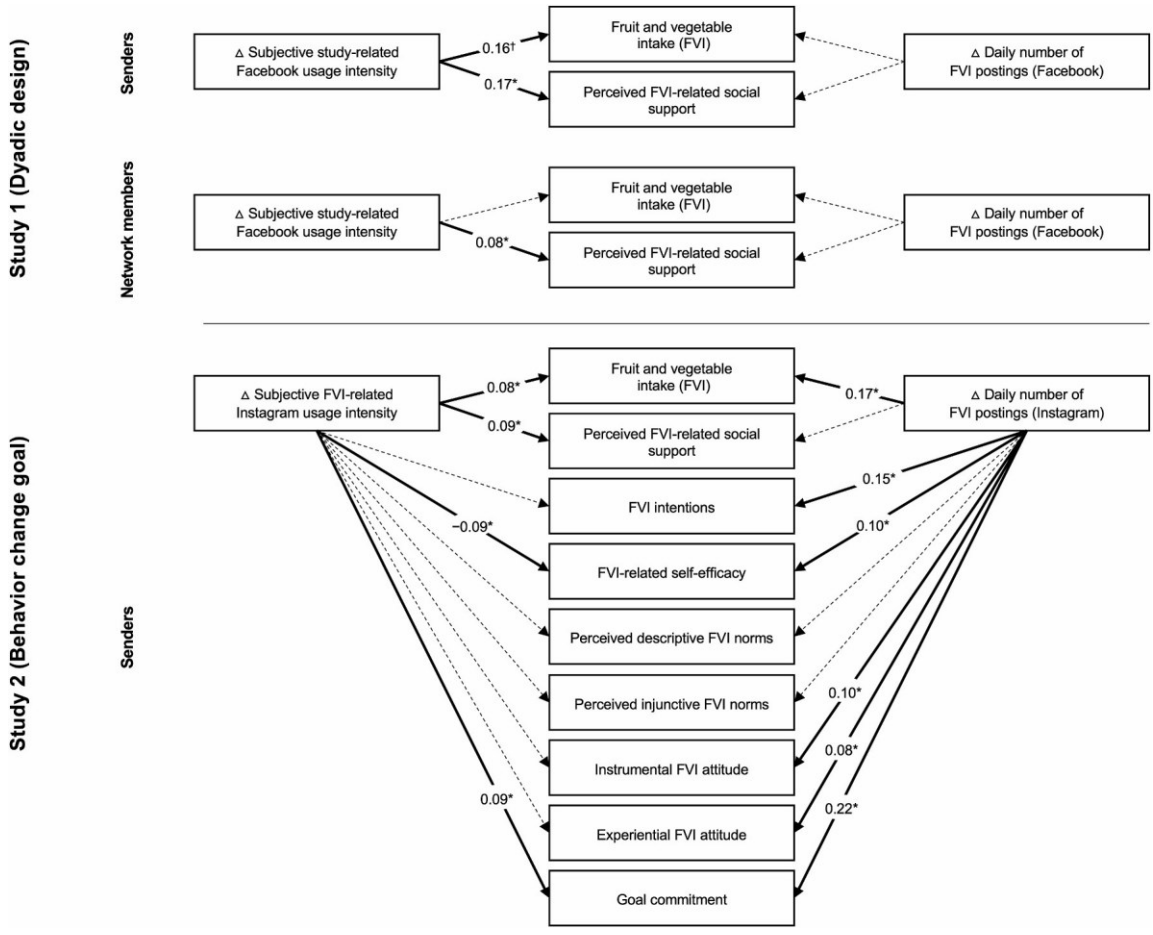

Fig. 3. Within-person effects of fruit and vegetable intake (FVI)-related social media activities on FVI and psychosocial outcomes in senders (Studies 1 and 2) and network members (Study 1).
Note. †p < .100, *p < .050. FVI = fruit and vegetable intake. Coefficients represent standardized estimates from multilevel models. Non-significant estimates are not shown for improved clarity. Study 1 had a dyadic design (sender + Facebook network member) without an additional behavior change goal for senders. In Study 2, senders participated alone but received a behavior change goal. In both studies, the effects on the different outcomes were estimated in separate models with the subsets of senders posting publicly about FVI on social media (and paired network members). Models were controlled for body mass index, age, education level, sex, amount of general daily Facebook (Study 1) or Instagram (Study 2) use, time since baseline (in days), and the number of daily surveys (only Study 1).

Table 2
Mean changes from baseline to follow-up in outcome variables for the private and public posting conditions (Study 2).

Outcome variable	Baseline – follow up (Δ)		Posting × Time interaction effect			Posting main effect			Time main effect		
	M (SE)										
	Private (n = 62)	Public (n = 66)	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
FVI	1.50 (0.46)*	1.51 (0.35)*	0.00	.984	.00	0.91	.341	.01	28.03	<.001*	.18
FVI intentions	0.04 (0.10)	0.30 (0.11)*	3.11	.080	.02	0.34	.561	.00	5.12	.025*	.04
Perceived FVI-related social support	1.29 (1.08)	0.23 (0.79)	0.65	.423	.01	0.26	.613	.00	1.32	.253	.01
Descriptive FVI norms	0.19 (0.12)	− 0.14 (0.10)	4.40	.038*	.03	0.39	.534	.00	0.10	.754	.00
Injunctive FVI norms	0.04 (0.16)	0.09 (0.11)	0.06	.805	.00	0.89	.347	.01	0.52	.474	.00
Experiential FVI attitude	0.09 (0.09)	− 0.01 (0.09)	0.62	.433	.00	0.45	.505	.00	0.45	.505	.00
Instrumental FVI attitude	− 0.17 (0.06)*	− 0.21 (0.09)*	0.13	.720	.00	0.39	.535	.00	11.18	.001*	.08
FVI-related self-efficacy Goal commitment	− 0.04 (0.09) NA[a]	− 0.04 (0.07) NA[a]	0.00 NA[a]	.955 NA[a]	.00 NA[a]	3.96 0.07	.049* .794	.03 .00	0.50 NA[a]	.479 NA[a]	.00 NA[a]

Note. F, p, and η_p^2 are derived from repeated measures analyses of variance. The significance level of the change scores shows the p-value from holm-corrected follow-up paired sample t-tests. FVI = fruit and vegetable intake. NA = not applicable. *p < .050. [a] Not applicable because goal commitment was only measured once at follow-up.

3.3. Method

3.3.1. Design and procedure

As in Study 1, we conducted a field experiment with baseline and follow-up assessment, EMA, and coding and analysis of public social media postings (both conditions) and private FVI-related postings (only private posting condition). Participants were recruited via Instagram advertisements, the study management systems of the University of Konstanz and the University of Mannheim, word of mouth recommendations, and flyers on the campus. Participants (senders) were randomized to one of two experimental posting conditions: (1) posting about their FVI publicly on their Instagram feed or (2) "posting" about

their FVI privately in a WhatsApp chat with our study account (i.e., uploading FVI photos without any feedback). This resulted in a 2 (posting: public vs. private) × 2 (time: baseline vs. follow-up) mixed design with additional daily diary data (Fig. 1). Thus, again, both groups tracked their FVI (BCTTv1: "2.3 Self-monitoring of behaviour"). Participants in the public posting condition additionally received responses (e.g., likes and comments) from their Instagram network (see Appendix C for all BCTTv1s). The study was approved by the Institutional Review Board of the University of Mannheim and preregistered via the Open Science Framework (https://osf.io/r7b9k/). Participants could choose between course credits or lottery tickets (for three 100€ online shopping vouchers) as compensation. The compensation was dependent on the number of daily FVI-related picture postings and completed questionnaires (see Appendix B).

At baseline, participants received an individualized goal to increase their daily FVI by 33% (BCTTv1: "1.1 Goal setting (behaviour)") for the upcoming week (e.g., participants who reported eating three portions of fruit and vegetables daily were asked to eat four in the upcoming week). The target portion number was feedbacked in 0.25 portion steps. Therefore, a 33% increase was calculated and added to the baseline value (rounding to the next lowest 0.25 portion if necessary). Participants were then randomized to their experimental posting condition. During the intervention week, participants received a daily invitation (at 8.30 p.m.) to a survey that assessed daily social media use, FVI, and psychosocial constructs. After the intervention week, participants answered the follow-up questionnaire.

3.3.2. Participants

Of the 204 initial participants, 146 (71.57%) provided follow-up data, and 128 (62.75%) with $N = 368$ daily surveys fulfilled inclusion criteria (Appendix D for participant flow chart). Participants in the final sample were $M = 22.74$ years old ($SD = 4.66$), the majority was female (89.06%) and had a medium education level (74.22%). There were few baseline differences between participants in the initial versus final sample: Participants in the final sample had fewer Instagram followers ($M = 272.59$, $SD = 239.13$ vs. $M = 425.03$, $SD = 483.22$), $t(95.61) = 2.55$, $p = .012$, $d = 0.44$, and a higher overall number of FVI-related postings (public + private postings combined; $M = 15.95$, $SD = 7.27$ vs. $M = 9.43$, = 7.44), $t(64.01) = -4.86$, $p < .001$, $d = -0.90$. There were no significant baseline differences between the two experimental conditions except that participants in the public condition reported higher daily Instagram use compared to participants in the private condition ($M = 71.92$ min, $SD = 48.48$ vs. $M = 52.36$ min, $SD = 37.65$), $t(121.77) = -2.56$, $p = .012$, $d = -0.45$, (see Appendix H for details).

3.3.3. Materials

3.3.3.1. Instagram data. Participants' postings in both posting conditions during the intervention week were saved and coded daily. The coded content was similar to Study 1 and included day and whether a posting was about FVI or not. 12% of Instagram postings (142/1224) and 12% of WhatsApp postings (171/1412) were coded by two raters. Intercoder agreement was high (Krippendorff's $\alpha = 0.883$ for content on WhatsApp, 0.868 on Instagram).

3.3.3.2. Baseline and follow-up measures. If necessary, all measures described here were adapted to the fruit and vegetable context. *FVI* in the last week was measured by asking how many servings of fruit [vegetables] participants typically ate per day in the last 7 days (Chapman et al., 2009). *FVI intentions* were measured with three items (Chapman et al., 2009; e.g., "I intend to eat fruit and vegetables several times a day"; Cronbach's $\alpha = 0.81$). *Perceived FVI-related social* support from the Instagram community was measured with nine items from the Frequency subscale of the CASSS-HB adapted to a Likert agreement scale (e.g., "In general, I have the impression that my Instagram community encourages me to eat more fruit and vegetables"; Cronbach's $\alpha = 0.83$). *Perceived descriptive and injunctive FVI norms* were assessed with four items each, adapted from FVI norm measures (Cullen et al., 2001; Di Noia & Cullen, 2015), and following measurement guidelines (Fishbein & Ajzen, 2011). For example, "In general, … I have the impression that most members of my Instagram community eat fruit and vegetables several times a day" and "… I have the impression that most members of my Instagram community approve of me eating fruit and vegetables several times a day" (Cronbach's $\alpha = 0.73$ and 0.88). *Instrumental and experiential FVI attitudes* regarding eating fruit and vegetables several times per day were assessed with nine semantic differential scales (Conner et al., 2011). For example, "I find eating fruit and vegetables several times a day" … "useless–useful" or "unpleasant–pleasant." (Cronbach's $\alpha = 0.80$ and 0.82). *FVI-related self-efficacy* for eating fruit and vegetables was assessed with seven items (e.g., "I am confident that I can eat healthy foods, such as fruit/vegetables, when there is junk food in my house") from the National Cancer Institute's Food Attitudes and Behaviors Survey (Erinosho et al., 2015; Cronbach's $\alpha = 0.78$ at baseline). *Goal commitment* regarding the goal of increasing one's own FVI was assessed with five items at follow-up (Klein et al., 2001), for example "I am strongly committed to pursuing this goal" (Cronbach's $\alpha = 0.81$). Control variables were measured only at baseline. They were equal to those in Study 1, except for general Facebook usage frequency, for which we instead assessed the *average daily duration of general Instagram usage (in minutes)* by asking how often participants used Instagram (daily vs. weekly) and for how many minutes (either per day or per week, depending on their first answer).

3.3.3.3. Daily measures. The daily questionnaires assessed daily FVI and FVI intentions, daily (FVI)-goal-related Instagram (public condition) or WhatsApp usage (private condition), and daily perceptions of the psychosocial constructs from the baseline and follow-up questionnaire. The items were adapted to capture daily experiences (e.g., "Today, I had the impression that my Instagram community encourages me to eat more fruit and vegetables"; see Appendix I). *Daily (FVI)-goal-related Instagram usage intensity* was assessed with "How much (how often and for how long) did you use Instagram today to communicate about your nutrition goal?" after reading a detailed description of different types of use (Verduyn et al., 2015).

3.3.4. Statistical analyses

All analyses were conducted as they were in Study 1, again using R version 4.1.2. Inclusion criteria were the same as in Study 1. We applied the same preregistered criteria for the group- and day-level analyses to match samples. In the dose–response analyses, FVI was not aggregated as in Study 1 because FVI was already assessed on the daily level. We fitted a linear mixed model because FVI was measured in 0.25 increments and normally distributed. We calculated a required sample size of $N = 126$ to detect medium-sized differences between both posting conditions at follow-up using GPower 3.1 (α-level = 0.05; statistical power = 0.80).

3.4. Results & discussion

3.4.1. Manipulation check for the posting manipulation

Participants in the public condition posted significantly more FVI- related Instagram postings ($M_{public} = 14.56$, $SD = 6.76$) than participants in the private posting condition ($M_{private} = 0.14$, $SD = 0.69$), $t(66.53) = -17.23$, $p < .001$; $d = -2.93$. Importantly, participants in both conditions published a similar overall number of FVI-postings, irrespective of posting condition ($M_{public} = 14.80$, $SD = 6.81$ vs. $M_{private} = 17.23$, $SD = 7.61$), $t(122.36) = 1.89$, $p = .061$, $d = 0.34$.

3.4.2. Group-level effects of posting

3.4.2.1. Effects of posting on senders' FVI and psychosocial outcomes. Senders who posted publicly compared to senders who posted privately about FVI did not show the expected significantly stronger increase in FVI (Table 2; Fig. 2). Thus, H1a was not supported. There was a main effect of time, indicating a significant increase of FVI from baseline to follow-up across both posting conditions (Table 2). The same pattern of effects was found for FVI intentions (Table 2). Importantly, a statistically significant increase in FVI intentions was specific to the public FVI posting condition ($p_{adj} < .020$) and, in line with H1b, the interaction with time was marginally significant ($p = .080$).

Psychosocial mechanisms were not significantly more positively affected by publicly posting about FVI (H2a–g; see Table 2). There was an interaction effect for perceived descriptive FVI norms, but the pattern was opposite of our expectation, with a trend for decreased descriptive norm perception in the public posting condition (Table 2). Furthermore, instrumental FVI attitude declined from baseline to follow-up in both groups (Table 2). Finally, participants in the public posting condition generally reported higher FVI-related self-efficacy than participants in the private posting condition (effect of Posting; Table 2). The mediation analyses showed that the hypothesized psychosocial mediators (see Appendix J) did not significantly explain the potential relations between posting about FVI and change of FVI or FVI intentions from baseline to follow-up. Thus, H3a-g were not supported.

3.4.3. Dose–response relationships between daily social media activities with daily eating and psychosocial mechanisms

We included 368 valid days of 66 participants in the public posting condition to examine dose–response relationships (see Appendix K and Fig. 3 for statistical details). We found positive dose-response relationships between the daily number of public FVI postings with daily FVI ($\beta = 0.17$, $p < .001$) and FVI intentions ($\beta = 0.15$, $p < .001$): On days on which senders posted more FVI postings than usual, they reported higher FVI and FVI intentions. Senders also reported higher FVI ($\beta = 0.08$, $p = .006$) but not significantly higher FVI intentions ($\beta = 0.04$, $p = .215$) on days on which they used Instagram more than usual. Thus, H4.1a was entirely and H4.1b partially supported.

We found positive dose-response relationships between the number of daily FVI postings and daily FVI-related self-efficacy ($\beta = 0.10$, $p = .015$), instrumental FVI attitudes ($\beta = 0.10$, $p = .003$), experiential FVI attitudes ($\beta = 0.08$, $p = .031$), and goal commitment ($\beta = 0.22$, $p < .001$). There were no significant relationships between the number of daily FVI postings and perceived FVI-related social support as well as descriptive and injunctive FVI norms. There were also positive relationships between the daily FVI-related Instagram usage and FVI- related social support ($\beta = 0.09$, $p = .004$), replicating the findings in Study 1. Further, daily FVI-related Instagram usage was positively related to goal commitment ($\beta = 0.09$, $p = .022$) and negatively with self-efficacy ($\beta = -0.08$, $p = .030$; see Fig. 3). In sum, H4.2g on goal commitment was fully supported; the hypotheses regarding perceived social support (H4.2a), self-efficacy (H4.2d), experiential attitudes (H4.2e), and instrumental attitudes (H4.2f) were partially supported. H4.2b and H4.2c on descriptive and injunctive norms were not supported.

4. General discussion

These are the first studies to experimentally test the effects of healthy eating-related social media activities on young adults' everyday eating behavior. Further, they also examined theoretically derived candidates for mechanisms of action. In two field experiments with additional intensive longitudinal and behavioral social media data, we examined the effect of posting about FVI on senders' and network members' FVI. In the main analyses, albeit we found a descriptively stronger increase in FVI when posting about FVI compared to a control topic (Study 1), this increase was not statistically significant. Exploratory post-hoc tests revealed that senders who posted about fruits and vegetables maintained their intake, senders who posted about a control topic decreased it. Network members exposed to FVI-related postings increased their intake whereas no change was observed in network members exposed to postings about the control topic. Posting supported senders in reaching healthy eating behavior change goals (Study 2); this effect was comparable to mere picture-based self-monitoring. Yet, we found initial evidence that public posting might increase healthy eating *intentions* more than self-monitoring. On days on which senders used social media more than usual (Studies 1 and 2) and made more healthy eating-related postings (Study 2), they also reported healthier eating. These findings extend previous cross-sectional studies by reducing recall bias through EMA (Shiffman et al., 2008). EMA and intensive longitudinal data further allowed us to examine *within*-person effects (e.g., intraindividual dose-response relationships between social media use and eating behavior). Furthermore, they extend laboratory studies by examining complex everyday eating behavior instead of simple food choices in the laboratory (Sina et al., 2022). They also provide first evidence for causal effects of healthy eating-related social media postings on healthy eating intentions and behavior by isolating the effects of public posting from the effects of mere self-monitoring of behavior. Interestingly, we also found dose-response relationships between daily healthy eating-related social media use and healthy eating behavior (FVI).

Study 1 further illustrated that FVI postings increased perceived FVI- related social support in senders and receivers of the postings, and perceived injunctive FVI norms of senders. While the experimental manipulations successfully evoked FVI social media postings in both studies, the effects on changes in FVI and other FVI-related psychosocial constructs were smaller than expected. One possible reason for these weaker effects is that one week of active social media posting might be too short for substantial changes; often, sustained health behavior changes takes several weeks or months (Kwasnicka et al., 2016). The effects of social media activities on psychosocial predictors and behavior itself might be transient and in temporal proximity to social media use. This is underlined by the positive dose-response relationships between daily FVI-related social media activities and attitudes, self-efficacy, goal commitment, social support, intentions, and FVI. As a result, FVI postings and related social media use may increase FVI and related cognitions on a given day; the overall effects may only accumulate slowly over time (see Scholz, 2019 for a discussion about the importance of theorizing temporal matters in health behavior change). Therefore, future research needs to consider between- and within-person effects when examining social media and health behavior change (see Dunton et al., 2021 for a related discussion on health behavior change in general), ideally over longer time intervals.

Surprisingly, we found little evidence for the role of psychosocial mechanisms of action underlying social media effects. Mechanisms of action may work in a more complex way and depend on the amount and content of social media postings and network responses on a daily level (Kilb & Mata, 2022). For example, within a weight-loss trial, the number of received comments in the social media group predicted self-efficacy change, whereas the connectedness of interaction partners predicted social support change (Xu & Cavallo, 2021).

4.1. Strengths and limitations

Our studies have several strengths. First, they combine experimental manipulation of social media behavior in the personal social media feeds of participants with daily diary and behavioral social media data. This provides a better understanding of between- and within-person effects of social media use on healthy eating behavior. It also allows to draw conclusions about the causality of potential effects of public social media postings on intention and behavior change by controlling for the effects of mere self-monitoring of eating behavior. Second, we looked at sender

and network member effects, thus capturing social media platforms' social interactivity. Third, we focused on one specific type of social media activity, healthy eating-related social media postings. Last, we tested theoretically derived mechanisms of action to explain how eating- related social media use affects offline eating.

The findings need to be interpreted considering the following limitations: Even though we used an experimental design to allow conclusions regarding the causality of effects, it is unclear which specific components or behavior change techniques might be triggered through public social media postings and cause potential effects. Increased public commitment and expected or received social reward, among others, might be important behavior change techniques (see Appendix C for suggested behavior change techniques at work). Therefore, future research should examine the relevance of those techniques and proxies (e.g., include additional experimental factors such as social feedback, or examine the amount of social feedback as moderating factors). Furthermore, some of the findings in Study 1 did not reach statistical significance due to the small sample size. We addressed this shortcoming in Study 2. We expected medium to strong effects of healthy eating- related social media posting. However, given that our studies isolated the *additional* effect of social media postings from other effective behavior change techniques such as goal-setting (Study 2) and self- monitoring (Studies 1 and 2), it is maybe not surprising that earlier studies combining a larger variety of behavior change techniques in the intervention arm (e.g., Inauen et al., 2017) found stronger effects than we did. In the dose-response analyses, the observational nature of the data does not allow to make causal claims. Therefore, future research should examine lagged within-person effects (Wickham & Knee, 2013). We nevertheless used person-mean centering for predictors (Enders & Tofighi, 2007) and controlled for several variables to minimize the impact of interindividual differences as potential alternative explanations. Another possible limitation is the use of incentives to motivate senders to comply with the posting intervention. Incentivizing network members (Study 1) further ensured that they have a minimum of exposure to senders' postings. As control and intervention participants received incentives for posting (senders) and reacting to condition-matching postings (network members in Study 1), between-group effects can be attributed to the posting content and not incentives itself. Incentivization is a common method in very time-intensive studies such as intensive longitudinal studies using EMA (Perski et al., 2022). In a recent experimental EMA study, performance-contingent monetary incentives did not impact data quality more than fixed monetary incentives (Giese & König, 2022). Furthermore, in a recent meta-analysis with more than 630 EMA studies, the authors found high average participant adherence and concluded that incentives do not influence adherence rate, suggesting that other factors such as intrinsic motivation might be more relevant for participation (Perski et al., 2022). Therefore, we do not expect a strong influence of our incentivization scheme on the study results. However, a strong interest in one's own behavior and related high intrinsic motivation could facilitate behavior change (Ntoumanis et al., 2021) and thus limit the generalizability to populations with lower personal interest in their behavior. Relatedly, participants in our studies were relatively homogeneous regarding education level, age, and gender. They reported healthy eating behavior already at baseline. This is another limitation on the generalizability of the results to other populations, such as people with less healthy eating habits, lower educational attainment, or lower socioeconomic status. There is initial evidence that social media-based health behavior interventions might also benefit less advantaged populations, but results are mixed and the number of studies is limited, so further research is needed (Petkovic et al., 2021). The potential ceiling effects in healthy eating may also explain why we did not find differences between public and private self-monitoring in Study 2. Another important aspect in the current studies is a potential social desirability bias. To reduce the impact of social desirability, participants were informed about the broad research questions, but not the specific hypotheses before completing the studies. Further, in both studies, we used an experimental design in which the intervention and the control group tracked and reported their eating behavior regularly. Therefore, social desirability bias should not disproportionally affect one group (e.g., only the experimental group) and therefore not bias the results concerning between-group differences. In the dose-response analyses, we combined subjective survey data with objective social media data which likely reduces the impact of social desirability bias on these results. Finally, our studies did not involve control groups without self-monitoring, which limits the conclusions regarding the effects of social media posting compared to no intervention in senders. However, this is also a strength, as we tried to isolate the effects of eating-related social media posting from self-monitoring of eating behavior.

5. Conclusions

Combining experimental manipulations of healthy eating-related social media posting, daily diary data, and objective social media data in two independent studies, we found initial evidence that healthy eating-related social media use can influence the eating behavior of senders and network members. The mechanisms of action underlying these effects remain mostly unclear, the most promising candidate being perceived eating-related social support. Our results suggest that the effects of social media on behavior and mechanisms are transient and depend on the social media activities (e.g., viewing, posting, or liking eating-related content), content of postings (e.g., personal successes, barriers), and reactions of the social network (e.g., supportive, socially approving). Future studies should use experimental designs with longer intervention periods, and researchers need to examine both, between- and within-person effects. Our experiments show that social media should be considered when researching the eating behavior of young adults.

Ethics approval and consent to participate

Ethical approval for both studies was obtained from the University of Mannheim before data collection. All participants gave written informed consent prior to participation.

CRediT author statement

Michael Kilb: Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Data curation, Project administration, Writing - Original draft preparation, Reviewing, and Editing. **Helge Giese:** Conceptualization, Methodology, Validation, Resources, Project administration, Writing - Reviewing and Editing. **Jutta Mata:** Conceptualization, Methodology, Resources, Funding acquisition, Project administration, Writing – Reviewing and Editing, Supervision. All authors have approved the final version of this article.

Declaration of competing interest

None. We have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

We uploaded the data to reproduce the main analyses on OSF and link to them in the manuscript.

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Supplementary data

Supplementary data to this article can be found online at https://hdl.handle.net/21.11116/0000-000C-7EDC-0.

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