

**The Role of Social Support in the Relationship Between Stress and Craving: A 100-Day  
EMA Study During Alcohol Addiction Treatment**

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### Abstract

**Introduction:** Alcohol use disorder (AUD) is very common, with attempts at abstinence often being accompanied by relapse. Previous research has found stress and craving levels to be related, acting as risk factors, leading to higher chances of relapse. At the same time, higher social support levels have been associated with improved chances at staying abstinent, moderating the relationship between craving and stress. A better understanding of such protective and risk factors, and their interplay, is of importance to inform better treatment options. **Method:** Data was collected in AUD patients over the span of 100 days, using an ecological momentary assessment (EMA) approach. In intervals of 3 hours, the participants ( $N = 4$ ) were asked to indicate their current stress and craving levels on a Likert-scale. Social support was assessed once, using the ISLE-12 questionnaire. Linear mixed models (LMM) and visualizations were used to inspect the relationship between stress and craving in each participant. A 3-hour lagged analysis and a moderation analysis between stress and craving, with social support set as moderator, were run on the complete sample. **Results:** The results of the individual LMMs showed a positive significant relationship between stress and craving levels, as did the lagged analysis. The moderation analysis, inspecting social supports effect on the relationship between stress and craving, did not yield significant results. When observing the stress and craving levels over time, the variability and individuality of their interplay becomes clear. **Conclusion:** In line with previous research, utilizing an EMA approach, stress and craving were found to be related, both concurrently and predictively. The significance of the lagged result may indicate stress-focused interventions to be of most value. Social support did not show a moderating effect on this relationship. This underlines the importances of investigating other social support measures or possible confounding variables.

*Key Words:* Craving, Stress, Social Support, AUD, EMA

## **The Role of Social Support in the Relationship Between Stress and Craving: A 100-Day EMA Study During Alcohol Addiction Treatment**

Alcohol use disorder (AUD) is a highly prevalent disorder (Carvalho et al., 2019; Glantz et al., 2019; Grant et al., 2015; Shmulewitz et al., 2021) associated with many health risks and mortality, such as through cardiovascular diseases, organ failure, and psychological disorders (Connor et al., 2016; Shmulewitz et al., 2021). AUD presents itself through inability to control alcohol consumption, craving, and emotional distress when not consuming alcohol (Carvalho et al., 2019). The far-reaching consequences, as well as the legality, acceptance, and availability of alcohol, make it a problem worth elucidating. According to the National Survey on Drug Use and Health from 2022, 29.5 million people had an alcohol use disorder (AUD) in the USA alone (*Alcohol Use Disorder (AUD) in the United States: Age Groups and Demographic Characteristics* | National Institute on Alcohol Abuse and Alcoholism (NIAAA), 06.02.24). Around 2.2 million people sought out treatment in the USA in 2023 (*Alcohol Treatment in the United States* | National Institute on Alcohol Abuse and Alcoholism (NIAAA), 06.02.24). However, not everyone who seeks treatment remains abstinent afterwards, and some persons relapse (e.g. Connor et al., 2016). Relapse can be defined as the reuptake of a substance misused by a person, of which they stayed abstinent from for a period of time (*APA Dictionary of Psychology*, 2024). As previous research has found, especially severe AUD is related to higher relapse rates (Tuithof et al., 2014). There are many possible factors at play when trying to understand why some individuals manage to stay abstinent, while others relapse. It is of great importance to gain a better understanding of those underlying protective factors as well as the risk factors which can lead to relapse. By identifying such factors one can inform effective treatment strategies.

One risk factor often mentioned and associated with relapse is craving. Craving is defined as an unyielding feeling of need and is often part of the diagnostic criteria used in order to determine whether someone is addicted to alcohol (*APA Dictionary of Psychology*, 12.08.24). In a meta-analysis by Cavicchioli et al. (2020), a significant positive association was found between craving levels and relapse in persons with AUD. Moreover, another article, inspecting how craving and relapse relate after discharge from inpatient treatment in DSM-IV diagnosed AUD patients, showed that high craving levels at the end of treatment were related to a higher risk of relapse up to 12 months after the end of treatment (Stohs et al., 2019). As is well-established, prolonged alcohol intake alters the brains' neurotransmitter pathways, leading to increased alcohol consumption in order to experience the positive effects of alcohol consumption such as more self-esteem or stress relief, creating the experience of

cravings (Connor et al., 2016; Sinha, 2008). Although the processes underlying craving are often unconscious, the experience itself is not (Kavanagh et al., 2013) and changes in the occurrence rates of cravings depend on the length of abstinence, with longer periods of abstinence relating to less moments of craving (Cless et al., 2023, Haass-Koffler et al., 2014; Kavanagh et al., 2013). Craving can present itself in different ways for different individuals (Anton, 1999; Haass-Koffler et al., 2014), ranging from obsessive thoughts about consuming alcohol (Anton, 1999) and elevated heart rates to negative emotions, anxiety, and stress (Haass-Koffler et al., 2014). It can be influenced by the context a person finds themselves in, thoughts about drinking, and conditioned stimuli based on past experiences (Anton, 1999; Kavanagh et al., 2013; Kuerbis et al., 2020), as well as by negative emotions such as stress and loneliness or the wish to feel more social (Kuerbis et al., 2020).

Stress, as it is an experience associated with cravings, has often been discussed in literature as a risk factor for relapse. Many previous studies have connected stress and relapse, with higher levels of stress relating to higher rates of relapse. Stress is defined as a response to stressors, which can be presented by the environment or come from within oneself, and it is said to be able to influence a person's behavior or affect (*APA Dictionary of Psychology*, 2024). A review by Sinha (2001) describes how stress has often been reported to be related to substance use as well as relapse and highlights how more research is needed to understand the relations at play. According to other research, during a time of abstinence, perceived stress can lead to negative emotions, which in turn can lead to people relapsing (Breese et al., 2005). Furthermore, Noone et al. (1999) reported that in their study, higher self-reported stress was predictive of relapses in their participants at a follow-up 1 month later.

In addition, the two risk factors, stress and craving, have also been found to be associated. In a laboratory study, stress inducing cues were found to lead to higher craving levels in abstinent AUD-patients compared to people who drink socially (Sinha et al., 2008), showing it to be an important factor to consider when inspecting people addicted to alcohol. Another study by Wemm et al. (2019), using a longitudinal approach, reported results in line with the previously mentioned article, adding that not only does stress predict a rise in craving levels, but also that these craving levels could predict relapse on the following day. This relationship between stress and craving was also found to exist in the opposite direction, with higher craving levels being associated with higher stress levels (Mayhugh et al., 2018).

As it is of importance to improve treatment and help people in trying to stay abstinent, a good understanding of possible protective factors of craving and relapse is crucial. One such protective factor often highlighted in literature is social support. Social support can be defined

as help received by other people in various forms, such as emotional or monetary support, which help with an array of possible stressors (*APA Dictionary of Psychology*, 2024), and has previously been linked to good health outcomes, such as better mental health, whilst a lack of social integration has been shown to lead to poor mental health (Seeman, 1996). Social support has also been shown to influence abstinence. A study by Ames and Roitzsch (2000) investigated addiction patients and the relationship between stress, craving, and social support. According to their findings, stress levels, and the number of stressful events, are predictive of craving levels. Moreover, they reported a significant moderating effect of social support on the relationship between number of stressors and craving. In a systematic review by Sliedrecht et al. (2019), high social support was found to be associated with lower rates of relapse. This indicates that emotional support and care help people refrain from the reuptake of alcohol. In line with this, social support negatively correlates with relapse and serves as both a good predictor for and protective factor against relapse (Jia et al., 2023). Moreover, Zaidi (2020) highlighted the many different forms in which social support can present itself and work, and its positive effect on addiction treatment outcome and relapse prevention.

All these factors affect the success of people staying abstinent and have been found necessary to investigate. Since AUD is a large societal problem, it is necessary to investigate its influencing factors and their relationships to each other further, but most studies have been conducted in laboratory settings, basing their results solely on one-time measurements. Since AUD is a complex disorder, affected by many variables, and addiction treatment is a long process, a deeper approach is necessary. One possible way of inspecting the relationship between these factors is with an ecological momentary assessment (EMA) approach. In EMA, participants are measured over a longer period, and it enables for the data to be collected in the natural context of the participants, thus ensuring ecological validity (Larson & Csíkszentmihályi, 2014; Moskowitz et al. 2009; Myin-Germeys et al., 2018; Scollon et al., 2009). As stress and craving are both variables which fluctuate a lot (Mayhugh et al., 2018) and are influenced by many factors such as context (Kuerbis et al., 2020), stress being induced in a laboratory setting does not represent stressors of the individual's actual life (Vaessen et al., 2015). Additionally, EMA counteracts the retrospective bias one might find in studies not using a momentary approach (Larson & Csíkszentmihályi, 2014; Moskowitz et al., 2009; Myin-Germeys et al., 2018; Scollon et al., 2009). This is another important benefit of the EMA approach, as it has been widely proven that experiences vary from memories, underlining the need to closely monitor participants in order to collect a reliable account of the investigated factors in their real-life contexts (Van den Bergh & Walentynowicz, 2016).

Moreover, due to its' repeated measures within individuals, EMA has proven a useful tool to inspect individuals and their changes over time (Morgenstern et al., 2014; Soyster et al., 2019)

The current paper aims to investigate the role of social support in the relationship between stress and craving, as well as the relationship between the two factors over time, applying the EMA approach. The possible moderating effect of social support on the relationship between stress and craving is of great interest. The findings could help improve treatment methods, as well as preventive implementations. This is necessary in order to be able to find the best possible ways of helping people with alcohol use disorder. If social support is found to moderate the relationship between stress and craving, treatment could aim at improving interpersonal skills, integrating family and friends, or group therapy sessions. If stress is found to affect craving, implementing stress reducing elements, for example relaxation skills training, could be a good approach.

To understand and investigate the interplay between the variables of interest, following research questions (RQ) have been formulated:

**RQ 1:** Are there differences in the relationship between stress and craving per individual?

It is hypothesized that the effect of stress on craving is positive and significant, with higher stress levels leading to higher craving levels, in all individuals. Furthermore, it is hypothesized that visual analyses will show distinctive patterns in the covariation of stress and craving across individuals.

**RQ 2:** Does stress have a predictive effect on craving?

It is hypothesized that a lagged analysis will show positive significant results, meaning that stress measured at a previous time point is indicative of the craving level measured at a later time point.

**RQ 3:** Does the level of social support moderate the concurrent relationship between stress and craving?

It is hypothesized that social support moderates the relationship between stress and craving, with higher perceived social support leading to a weaker direct effect between stress and craving. Furthermore, it is hypothesized that people in the high social support group experience less intense moments of craving and stress.

The results of the first RQ will form the basis of the moderation analysis, as it would indicate that the results are truly due to moderating effects and not due to variances in the primary relationship. In addition, the possible buffering effect of social support can be

explored by the means of a moderation analysis and more qualitatively, by making use of visualizations to explore whether patterns between individuals are visible.

### **Methods**

The data was collected by van Lier et al. for their 2022 study (see van Lier et al., 2022 for all following information), which followed an ecological momentary assessment approach. The research team received ethical approval from the Medical Ethical Committee Twente (registration number: NL58392.044.16). The original data set consisted of multiple additional variables, and included data collected with a wristband measuring cardiovascular and electrodermal activity. These were not of interest for the present study.

### **Participants**

The original data was collected on 10 participants over a 100-day period. The following analyses will focus on four out of these 10 participants, as the social support scores were only available for those 4 participants. The participants were recruited from fall 2016 till spring 2017, and approached in face-to-face addiction clinics in the Netherlands, as well as through an online outpatient platform in the Netherlands. Before participating, each patient needed to set their goal as wanting to stay abstinent from alcohol and needed to have had at least 6 weeks of treatment. All included participants had moderate to severe substance use disorder according to the DSM-5. Other diagnoses were seen as an exclusion criterion, as well as the misuse of other substances other than alcohol. Each participant filled out and signed a consent form. Of the ten participants, 6 were male and 4 were female. The participants had to be at least 18 years of age, with the average age being 40 ( $SD= 11$ ). The demographics of the four participants whose data was used are unknown.

### **Procedure**

At the beginning of the study, demographic information was collected on every participant. Four participants filled out further questionnaires, one of which assessed their perceived social support, which is of interest to this study. The study made use of a time-contingent design, meaning questionnaires were sent following a fixed sampling schedule. This is a common practice in EMA studies (de Vries et al., 2021). Each day, the participants received prompts on their mobile phones; in the morning and evening for two questionnaires, as well as prompts 8 times a day in 3-hour intervals from 1 a.m. till 10 p.m. for multiple questions. The number of prompts is in line with reported frequencies in EMA studies (de Vries et al., 2021). Furthermore, one questionnaire was sent at the end of each week. The participants had 1 hour to respond to the questions.

Due to the longitudinal assessment approach employing multiple assessments during

the day in 3-hour intervals over a longer time period, the use of single-item measures and short answers via a Likert scale was seen as the least burdensome to participants. Using single-item measures is a common practice in EMA studies (de Vries et al., 2021) and has been shown to be as reliable as multiple-item measures (Song et al., 2022). For each completed questionnaire each participant could receive 1 euro compensation, implemented as an additional incentive.

## **Measures**

### ***Self-reported Stress and Craving***

Most of the items were asked to be answered on a Likert scale ranging from 0-10. Stress was measured as such, with higher scores indicating more perceived stress. The participants were asked to indicate their stress levels in the moment; it was not measured retrospectively. The question read: ‘How stressed are you in this moment?’.

Craving was also measured for the moment of prompt on a Likert scale ranging from 0-10, with a higher score indicating higher levels of craving. The question read: ‘How strong is your craving currently?’.

### ***Social Support***

Social support was only measured as a baseline score at the beginning of treatment, so only one value is available. 9 out of the 12 items of the ISLE-12 questionnaire were used (see Appendix). This questionnaire groups the items in three subscales, namely ‘appraisal’, ‘belonging’, and ‘tangible’. These relate to perceived presence of someone to speak to about issues, someone to spend time with, and someone who would offer material help, respectively (Carnegie Mellon University, 15.08.2024; Cohen et al., 1985). Participants used a Likert scale to answer each item going from 0= definitely false, 1= probably false, 2 = probably true, to 3 = definitely true. The scores were calculated using scoring instructions (Carnegie Mellon University, 15.08.2024). A higher score is indicative of higher social support and the scores range from 0 to 27. Some items were reversed coded.

## **Data Analysis**

The analyses were conducted using *IMB SPSS statistics* (29.0). In order to prepare the data set for the analyses, variables not of interest to the research questions were deleted. Next, each participants’ social support score was computed, and they were grouped in high and low social support for the purposes of the research.

First, to get a good overview and general picture of the variables of interest (stress and craving), descriptive statistics were run. Next, four separate Linear Mixed Models (LMM) were applied to investigate the relations between the independent variable stress (IV) and the



dependent variable crave (DV) in the single individuals, to see whether the hypothesized relationship between stress and craving exists in all participants. Linear mixed models are deemed suitable for analyzing longitudinal data sets since they are fit to deal with the dependency between data points, can handle missing data points, and one can set time varying as well as non-varying variables as predictors (West, 2009). The autoregressive covariance setting AR (1) was employed, as the correlation between the different data points was predicted to diminish with increasing distance (Barnett et al., 2010). All other following LMMs were employed using the autoregressive covariance setting AR (1) also.

Afterwards, single case graphs were created to explore and visualize the relationship of the variables of interest over time, comparing each individual as well as inspecting for obvious differences in the graphs of the high versus low social support individuals, to see whether patterns are visible. For the purposes of these graphs, the daily means of stress and craving were used. This was done for easier readability of the graphs, simpler comparability between the high and low social support individuals, as well as for the inspection of possible general trends. The level and number of peaks were visually inspected and compared, as well as the spread of peaks over the course of 100 days in order to check for possible downwards trends or changes in covariation over time. As the LMMs inspect the momentary relationship between the variables, this method adds another level to the research, showing whether it is necessary to look at single moments to fully understand the covariance of the variables.

A lagged analysis was conducted on the whole sample ( $N = 4$ ), applying a LMM, using a 3-hour lag of the variable stress. For this, a new variable for stress was created, by shifting its values back by one time point. This aligns the stress value from the preceding 3-hour time point with the corresponding craving measurement 3 hours later. This aimed to identify a possible predictive effect of the variable of interest stress (IV) on craving (DV).

For the main purpose of this study, a LMM was conducted for the moderation analysis, using the data of all four participants combined ( $N = 4$ ). Crave was set as the dependent variable (DV), whilst stress and social support (both fixed effects) acted as independent variables (IV), and the interaction term between stress and social support was included as the moderator. Participant ID was set as the random effect. This was done to inspect whether a significant moderating effect can be found.

### ***Post-Hoc Analyses***

Post-hoc, additional analyses were run. To verify the use of daily means in the graphs, LMMs were employed for each individual using the daily averages of their stress and craving levels. To inspect whether a clearer weekly trend or pattern would become visible when

looking at a smaller timeframe, graphs were created using the daily averages of stress and craving inspecting 3 weeks in the middle of the data collection period. This period was chosen in order to ensure a stable representation of the variables whilst avoiding overcrowding in the graphs. Lastly, to inspect whether the direct effect found in the moderation analysis was based on within- or between-person effects, another LMM was run, using person-mean centering, a technique often used in longitudinal studies. Here, the mean of the individual is subtracted from the single data points to capture the variation around the person's mean (Hoffman & Stawski, 2009). This way, one can inspect how much the data points deviate from the overall average of the individuals. The person means as well as the person-centered means of stress were set as the independent variables (IV) whilst craving was set as the dependent variable (DV).

## Results

### Descriptives

Descriptive statistics were run for a clear summary and overview of the variables of interest (Table 1). The participants were grouped in high and low social support with IDs 429 and 587 belonging to the low social support group and IDs 624 and 923 to the high social support group.

**Table 1**

#### *Descriptive Statistics*

ID	Craving		Stress	
	<i>N</i>	<i>M(SD)</i>	<i>N</i>	<i>M(SD)</i>
429	311	1.51 (2.7)	314	1.62 (1.62)
587	224	2.83 (2.89)	228	3.89 (2.29)
624	301	.88 (1.91)	303	.77 (1.7)
923	327	1.15 (1.84)	327	2.84 (1.44)
Overall	1163	1.51 (1.84)	1172	2.18 (2.08)

*Note.* *M* = Mean, *SD* = standard deviation

### Linear Mixed Models

Linear mixed models (LMM) were employed to inspect the relationship between stress and craving per participant, using all measurements available.

The results of the LMMs inspecting the link between stress and craving showed a significant positive relationship between the two variables at a  $p = 0.05$  level for all participants (Table 2). This is indicative of higher stress levels being associated with higher

craving levels in each participant. For participant 429 this interaction was lowest ( $b = .34, p = <.001$ ) and for participant 587 highest ( $b = .79, p = <.001$ ). As reported later in the moderation analysis, the relationship between stress and craving including all participants also showed to be significant ( $b = .61, p = <.001$ , see table 4).

**Table 2**

*Estimates of Fixed Effects of Stress (IV) on Crave (DV)*

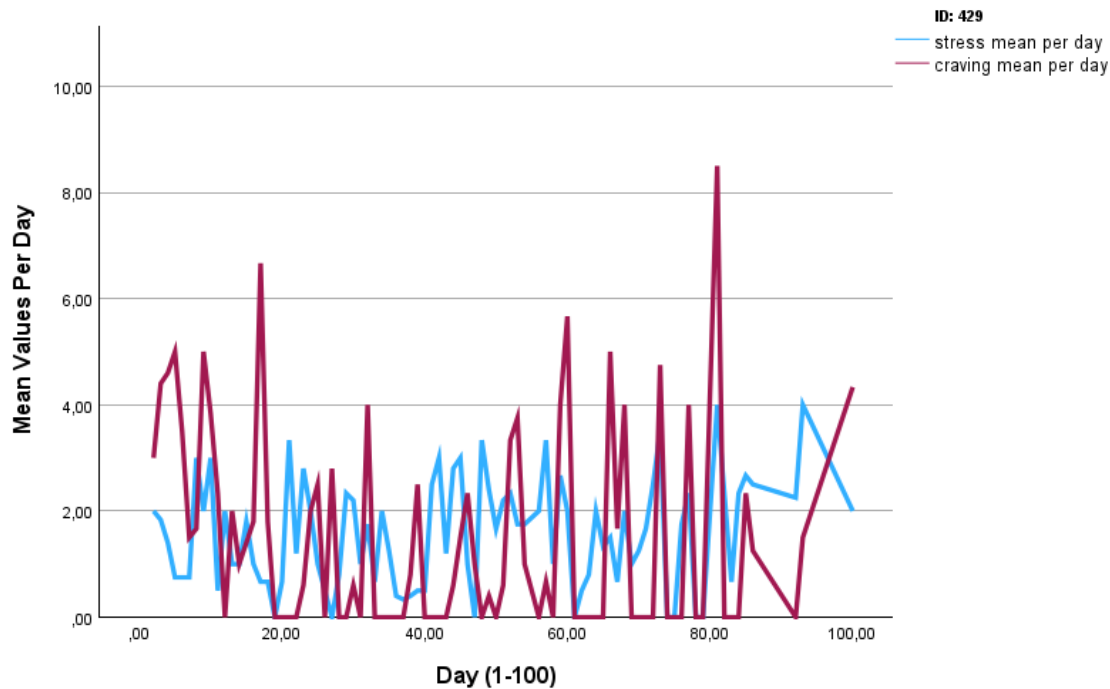
Group	ID	Parameter	Estimate	SE	df	t	Sig.	95% CI	
								LL	UL
Low social support	429	Intercept	.95	.24	150.21	4.02	<.001	.48	1.42
		Stress	.34	.09	276.21	3.89	<.001	.17	.52
	587	Intercept	-.27	.30	170.61	-.88	.38	-.87	.33
		Stress	.79	.06	200.93	13.21	<.001	.68	.91
High social support	624	Intercept	.36	1.04	.00	.34	1.00	-15.24	15.95
		Stress	.70	.05	298.80	13.57	<.001	.60	.80
	923	Intercept	-.01	.23	218.50	-.05	.96	-.46	.43
		Stress	.41	.07	276.45	5.86	<.001	.27	.55

*Note.*  $p = 0.05$ ,  $df$  = Degrees of freedom, CI = confidence interval, LL = lower limit, UL = upper limit.

### Single-Case Graphs

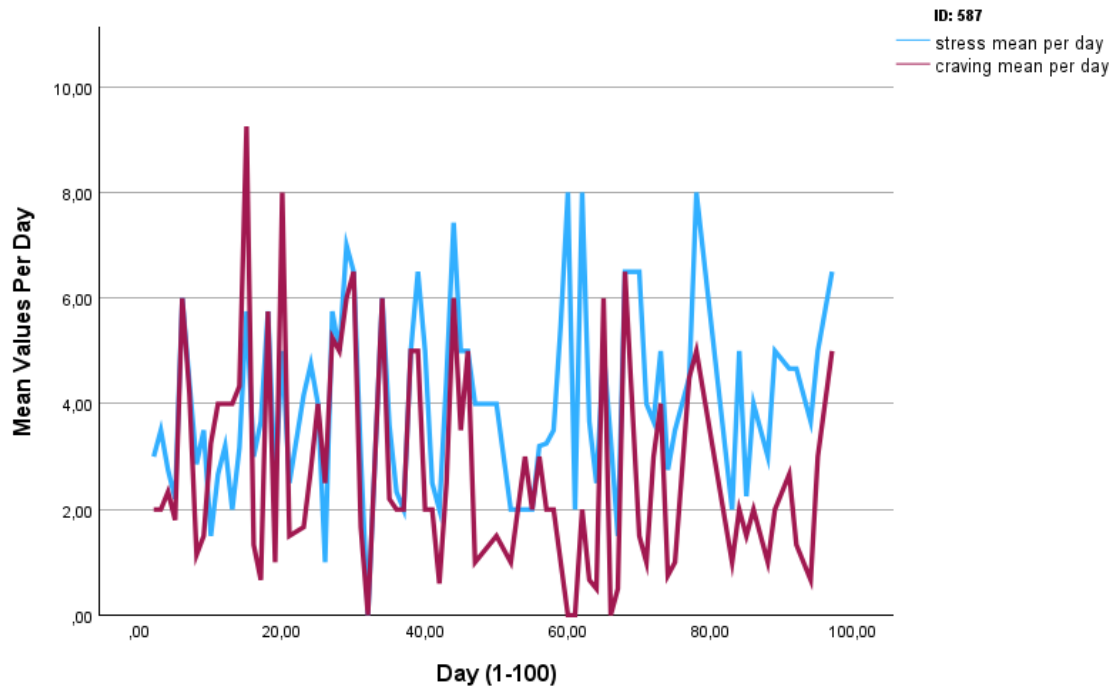
In order to inspect the relationship between stress and craving as well as the fluctuations within these variables, single case graphs were created using the daily means of each participant. These are also used in order to see whether pattern differences become apparent between the two groups of high and low social support. Each graph depicts two lines, representing the variables of interest, over the course of the 100 days in treatment. LMMs conducted post-hoc on the relationship between the daily average of stress and the daily average of craving yielded significant results in all participants, verifying the use of daily means in the graphs shown above.

Figure 1 shows the graph of participant 429, belonging to the low social support group. As one can see, both variables fluctuate considerably across the span of 100 days. Whilst stress stays more consistent, craving seems to be episodic, peaking multiple times between intervals of no craving. No clear relation or downward trend is visible. The post-hoc linear mixed model showed a significant positive relation between the daily mean of stress and the daily mean of craving ( $b = .52, p = <.001$ ).

**Figure 1***Daily Means of Stress and Craving Over 100 Days in Participant 429*

Note. The figure depicts the daily means of the variables stress and craving over a 100 day period.

Figure 2 depicts the development of the two variables for participant 587. Similarly to the first graph, it shows large fluctuations during the hundred-day period, with no clear trend visible. Other than in the first graph, stress appears to peak more often, not always accompanied with spikes in craving in the second half of the time period. In the first half, some overlap is visible, indicating covariance. The post-hoc linear mixed model showed a significant positive relation between the daily mean of stress and the daily mean of craving ( $b = .72, p = <.001$ ).

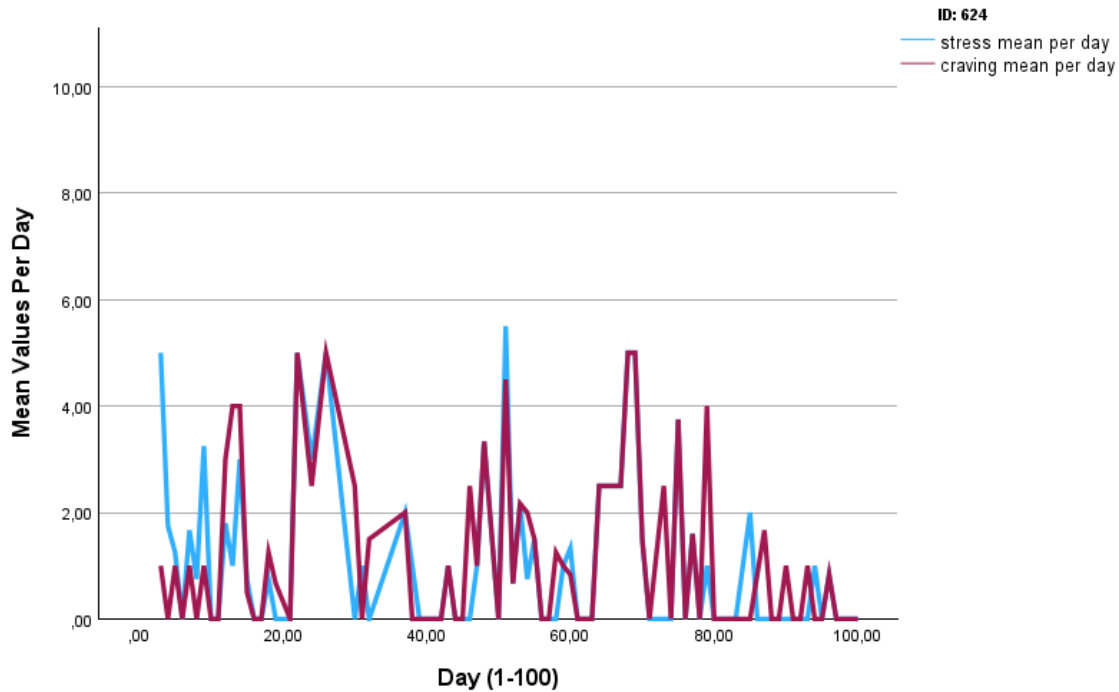
**Figure 2***Daily Means of Stress and Craving Over 100 Days in Participant 587*

Note. This figure depicts the daily means of the variables stress and craving over a 100 day period.

In Figure 3, the daily means of participant 624 are shown. Compared to the other two graphs, the daily means are lower on most days. The two variables seem to move together more closely than in the other two graphs, with higher stress often being accompanied by higher craving and the other way around. The post-hoc linear mixed model showed a significant positive relation between the daily mean of stress and the daily mean of craving ( $b = .76, p < .001$ ).

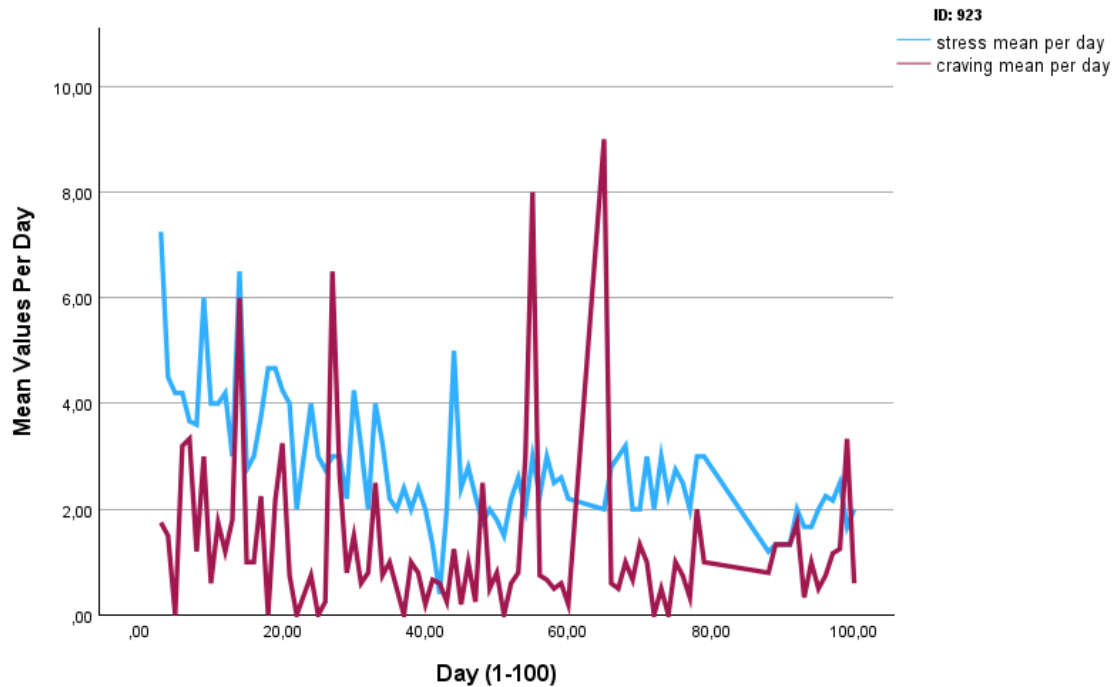
**Figure 3**

*Daily Means of Stress and Craving Over 100 Days in Participant 624*



*Note. This figure depicts the daily means of the variables stress and craving over a 100 day period.*

Figure 4 shows more consistent stress and craving levels, though craving peaks at multiple time points, whilst staying low for most of the duration of 100 days. The means of stress and craving do not overlap as much as in the other graphs. The post-hoc linear mixed model showed a significant positive relation between the daily mean of stress and the daily mean of craving ( $b = .36, p = <.001$ ).

**Figure 4***Daily Means of Stress and Craving Over 100 Days in Participant 923*

Note. The figure depicts the daily means of the variables stress and craving over a 100 day period.

Overall, the two participants in the low social support group (Figures 1 and 2) seem to experience more variability in their mean scores of stress and craving over time. They also appear to experience more intense moments of craving and stress, with more peaks. In general, it is visible that each individual's relationship between stress and craving differs. No clear downwards trend of the stress and craving means was found. When looking at the graphs, craving seems to slightly decrease over time in two participants (Figures 2 and 4) while remaining stable in the other two. Stress seems to slightly decrease in the two high social support individuals but not in the other two where it seems to increase slightly. The covariance seems relatively stable across time in all participants.

For further investigation, graphs were created post-hoc, zooming in on a three-week period for each participant, trying to see whether weekly patterns would emerge. This was found not to be the case.

### Predictive Effect

A lagged LMM was run for further exploration of the effect of stress on craving. A 3-hour lag of stress prior to the craving measure was employed to see whether a predictive effect is present. The effect was found to be significant ( $b = .26, p = <.001$ ; Table 3). This

indicates that stress measured 3 hours prior is predictive of craving levels measured 3 hours later.

**Table 3**

*Estimates of Fixed Effects with lagged (t-1) Stress as Independent Variable and Craving as Dependent Variable for all Participants*

Parameter	Estimate	SE	df	t	Sig.	95% CI	
						LL	UL
Intercept	1.25	.42	3.35	2.96	.05	-.02	2.52
Lagged_Stress	.26	.05	599.81	4.91	<.001	.15	.36

*Note.*  $N = 4$ ,  $p = 0.05$ ,  $df$  = Degrees of freedom, CI = confidence interval, LL = lower limit, UL = upper limit.

### **Moderation Analysis**

A moderation analysis was run using all observations, encompassing all 100 days of treatment, in order to inspect the effect of social support on the concurrent relationship between stress and craving (Table 4). High social support was used as the reference group in the analysis. Stress and social support were set as the independent variables (IV) and crave as the dependent variable (DV). The results show a positive significant relationship between stress and craving ( $b = .61$ ,  $p = <.001$ ), indicating that higher stress levels are associated with higher craving levels. The direct effect of social support was found to be negative, but not significant ( $b = -.47$ ,  $p = .44$ ). The interaction term of social support and stress was found to be negative and non-significant ( $b = -.05$ ,  $p = .51$ ), meaning that social support does not moderate the relationship and that for people with higher social support, the direct effect of stress on craving is neither weaker nor stronger.



**Table 4***Moderation Analysis 100 Days with Craving as Dependent Variable*

Parameter	Estimate	SE	df	t	Sig.	95% CI	
						LL	UL
Stress	.61	.05	892.16	13.27	<.001	.52	.70
Social-Support	-.47	.50	2.34	.93	.44	-2.35	1.42
Interaction	-.05	.07	868.92	-.66	.51	-.18	.09

*Note.*  $N = 4$ ,  $p = 0.05$ ,  $df$  = Degrees of freedom, CI = confidence interval, LL = lower limit, UL = upper limit.

### Within- and Between-Person Effects

Using the method of person mean centering, an analysis was conducted post-hoc to investigate whether the direct link between stress and craving in the moderation analysis (Table 4) is driven by within or between person effects. The results showed a significant positive within-person effect ( $b = .59$ ,  $p = < .001$ ) and no significant between-person effect ( $b = .48$ ,  $p = .20$ ). This indicates that in each individual higher stress levels are associated with higher craving levels, but since the between-person effect is not significant, this indicates there not being a consistent relationship between stress and craving across individuals based on averages.

### Discussion

The aim of the current study was to inspect the relationship between the risk factors, stress and craving, as well as the possible buffering effect of social support on their relationship within AUD patients. Data was collected over the span of 100 days using an EMA approach, setting it apart from previous research in the field. To answer the research questions, single case linear mixed models and graphs were employed to inspect the relationship between the variables stress and craving. A lagged analysis was run on all cases to inspect whether a predictive relationship exists between stress measured 3 hours prior to a craving measure. Lastly, a moderation analysis was conducted to inspect whether social support acts as a moderator in the relationship between stress and craving.

### Key Findings

The single case LMMs all showed a positive significant relation between craving and stress across all participants. This was expected as previous research has also found a strong and consistent link between these two variables (e.g. Law et al., 2016; Mayhugh et al., 2018;

Sinha et al., 2008). Furthermore, the single case graphs of the daily means show more covariance in the participants with a stronger relationship as indicated through the results of the LMMs. Thus, supporting the findings of the LMMs, as do the main effects found in the moderation analysis. When comparing the graphs, as well as mean scores of the individuals with high social support and low social support, the participants belonging to the high social support group appear to experience fewer peaks in their craving and stress levels, as well as lower mean scores. This would support the idea of a potential buffering effect of social support, shown previously through lower reported stress levels (Cohen & Hoberman, 1983), predicting relapse outcomes (Jia et al., 2023; Nikmanesch et al., 2016), and a moderating effect of social support on stress and craving (Ames & Reitzsch, 2000). However, the differences between the high- and low social support group individuals are not as clear as initially expected. No clear weekly patterns were visible in the graphs in any of the participants, regardless of group, highlighting the volatility of both experiences. The participants of both groups experienced peaks in cravings as well as in stress levels, and all participants experienced fluctuations from day to day underlining that higher social support does not fully protect a person from experiencing higher levels of stress or craving, and that the results might hint at only a subtle buffering effect. As Mayhugh and colleagues (2018) demonstrated in their EMA study, both stress and craving vary largely throughout the day. Based on this finding, inspecting fluctuations within-day, instead of inter-day, might have been more advantageous.

No clear downwards trend of the stress and craving means was found either. However, changes over time were not analyzed by statistical means, neither whether the levels decreased significantly nor the correlation between the two variables. A possible explanation for not finding a clear downwards trend could be the fact that the participants were already in treatment for at least 6 weeks at the point of data collection. If the treatment did influence the stress and craving levels of the participants, this effect may have been missed if it mostly occurred in the first few weeks of treatment. The low mean scores of the participants as well as the low standard deviations suggest this as well. Within this timeframe, participants could have already learned and started to employ skills to lower their stress and craving levels. Studies have demonstrated positive significant effects on coping-skills and emotion-regulation after treatments consisting of only six (Chen et al., 2016) and eight sessions (Zandi et al., 2021) and have shown treatment to lead to lesser levels of perceived stress and craving through mindfulness-based interventions (Cavicchioli et al., 2018), lessen craving and improve self-efficacy through cognitive behavioral therapy (Loeber et al., 2006), and lead to

more usage of those learned skills (Rohsenow et al., 2001).

The lagged analysis yielded significant results, using a three-hour lag. This indicates that within this data set, stress measured three hours prior is predictive of craving levels measured three hours later. These findings are in line with previous research which has shown a predictive effect of stress on craving (Clay et al., 2018; Higley et al., 2011; Law et al., 2016; Wemm et al., 2019). Panlilio and colleagues (2021) found, in an EMA study inspecting people with substance use disorder, craving decreased within 90 minutes after experiencing high levels of stress, marking this as a high-risk period. The significance of the 3-hour lagged analysis shows that, although stress and craving are highly dynamic (decreasing within 90 minutes), high levels of stress may impact craving measured 3 hours later.

Furthermore, the moderation effect of social support on the concurrent relationship between stress and craving was tested. No significant interaction term was found, which indicates that higher social support does not lead to less craving in high stress moments. This finding is not in line with previous research which often reports a buffering effect of social support, as mentioned above. As an example, using the ISLE, Cohen and Hoberman (1983) found social support to protect from negative consequences caused by high stress levels. A possible explanation for the lack of a significant result is the small sample size, which can lead to an inability to detect an existing relationship (Lyman, 2019, Makin & Orban, 2019). Though repeated measures within individuals can counteract this problem (Makin & Orban, 2019), this only accounts for within-person findings. Furthermore, this has consequences on the generalizability of the findings, meaning the results are to be taken with caution. As the sample size is small, it might not give an accurate representation of the population of interest. It might also underline how variable the relationship is, and how other factors might be of more importance, at least to certain subgroups such as in the current sample.

Another possible explanation for the lack of a significant result could be the measure used for social support. As social support was only measured at baseline, the relationships could have changed in the 6 weeks before the start of data-collection, which would mean that the groupings in high and low social support may no longer have been accurate when looking at the 100-day period. In addition, the type of social support and the people involved are important to take into consideration. For example, one may have high perceived social support, but this support exists of persons who are not aware of the AUD treatment, due to participants being ashamed of their diagnosis and treatment. A review by May et al. (2019) found shame to be one of the most important reasons for people to not seek out treatment when dealing with AUD. As another article showed, shame was a prevalent topic in people

undergoing treatment and is essential to consider when aiming to ensure a positive treatment outcome (Sawyer et al., 2019). It is reasonable to assume that for some people in the current data set shame was a relevant topic, and it is unknown whether the topic was addressed in treatment, or whether it kept them from sharing about it with people in their social support circle. Thus, participants might not reach out during times of distress related to craving. Furthermore, the social support circle may consist of persons who also drink, which might mean that when people seek out support or company, alcohol might be present. This could lead to higher stress or craving levels in the moment. Although, the moderation did not find any significant result in either direction. As research has found, the social circle of a person is highly influential to an individual's drinking behavior, with increased consumption in the network leading to increased consumption in the person (Rosenquist et al., 2010). Additionally, it has been reported that people from non-craving related contexts provide better social support in people with AUD compared to the ones in craving-contexts (Braus et al., 2022). The measure used here to assess social support was a generic one, not specific to support during addiction treatment. Thus, none of the previously mentioned aspects were controlled for. As a study by Wasserman et al. (2001) showed, a social support measure related to abstinence specific themes such as number of persons who are also users, or exposure to the substance, was shown to be related to the abstinence outcome in cocaine addicts.

These results may also hint at social support in fact not having an effect on the relationship between craving and stress in this group of participants. As previously argued, one possible reason is that the participants are already in treatment, learning coping-skills, which may lead to them relying more on their own skills and experiences than on other people. They could have built a trust in their own motivation, skills, and resilience. As Loeber et al. (2006) for example have shown, treatment can lead to patients feeling more self-efficient and able to handle moments of craving. In line with this finding, Nikmanesh and colleagues (2016) found the believe in one's own self-efficiency to be one of the best predictors of relapse, with higher beliefs in oneself leading to less moments of relapse. Studies have demonstrated positive significant effects on coping-skills and emotion-regulation after treatments consisting of only six (Chen et al., 2016) and eight sessions (Zandi et al., 2021). Though these studies were not particularly aimed at addicted patients, it is still reasonable to believe that by the time of data collection participants had already taken a big step towards applying better coping-mechanisms. As a meta-analysis by Magill and Ray (2009) reported, analyzing cognitive behavioral treatment in persons with AUD and other substance use

disorders, the effects often subside with continuing treatment, supporting the approach of shorter treatment periods.

Additionally, other factors could simply play a larger role than social support. As has been reported, AUD is a complex disorder, with many factors influencing its course and persistence. The results of other studies as well as this current one might have been influenced by confounding variables not inspected, such as comorbidities (Gavurova et al., 2022), negative affect and context (Kuerbis et al., 2020), or personality traits (Clay et al., 2018). Social support also may have had a buffering effect, but this effect may have faded away as the treatment went on within the first 6 weeks, or other variables have become more influential.

The direct effect of stress on craving in the moderation analysis was found to be significant, and a post-hoc analysis suggested that this effect is driven by within-person factors. This finding has multiple possible explanations. For one, as mentioned above, the sample size might not be sufficient to detect between-person effects, which usually requires a larger sample (Dieleman & Templin, 2014). Furthermore, it might be the case that the overall average stress and craving levels are too similar in the sample to lead to significant between-person effects. In addition, the participants in the sample might be too similar and too much homogeneity might be present to detect between-person effects, as the differences might not be large enough to be statistically significant. Due to the fact that all participants are patients in treatment for mild or severe alcohol use disorder, all living within the Netherlands, this seems plausible. These findings might also indicate that the contexts in which a person finds themselves might be of more importance than stable traits, underlining the importance to include those in research.

Ultimately, what becomes clear is that craving, and stress are both factors with high variability, the relationship of which is not to be simply explained by one variable such as social support. The relationship between the two variables, though highly dynamic, is present in each individual in this study and driven by within-person factors. It remains consistently varied over the course of the 100 days the current study took place. No extreme differences were observable in the graphs of the high- and low-social support individuals hinting at group-differences, but rather each graph displayed a distinct pattern. As the lagged analysis has shown a predictive effect of stress on craving, looking at the predictive effects, with a focus on stress, seems of value when investigating the interplay of factors in alcohol use disorder.

### **Strengths, Limitations, and Future Research**

When looking at the current study, one strength becomes very apparent. The EMA approach allowed for multiple measures across a long period of time, resulting in many data points for each participant. This provides the possibility for a lagged analysis that guarantees for the timely order of the measurements, as well as more data to base findings on. The fact that the factors both fluctuate substantially underlines the importance of multiple measures per participant for an accurate overview of their covariance. As a review by Mengelkoch et al. (2024) reported, EMA is a highly useful approach when trying to capture daily variations as well as changes over time in the variables of interest and can be useful when trying to inform better treatment options. Furthermore, an article by Shiffmann (2009) also mentioned benefits of using an EMA approach in an AUD study, ranging from capturing the short-liveness of emotions, avoiding recollection-bias, as well as being superior in capturing individual patterns and the relationships between variables to simple questionnaires. Additionally, it has been reported that addicted participants do not object to partaking in an EMA study (Markowski et al., 2021). Data-collection spanning the course of 100 days is a remarkable achievement, as reviews report average durations of 1 week (Wrzus & Neubauer, 2023) and 5 weeks (Serre et al., 2015), while still maintaining the benefits of EMA, setting it apart from other studies. Furthermore, AUD is a complex disorder influenced by multiple factors, such as the setting in which a participant finds themselves, this makes it important to inspect their relationship in the participant's natural surroundings. As an EMA study by Kuerbis and colleagues (2020) reported, the context in which a person finds themselves and whether they perceive it as prompting the desire to consume, or consumption itself, are related to higher levels of craving. The contexts which are deemed risky to people is highly individual and differs greatly between people. Thus, one apparent recommendation for future research is the use of the EMA approach. Future studies can make use of prolonged data-collection to compare different periods in order to inspect whether changes in the relationship between the variables stress and craving occur, or whether the effect of social support changes over time. In addition, daily fluctuations within the variables could be examined. This could aid in informing the set-up and schedule of interventions. Additionally, more research on the predictive effect of stress is of great importance, as pinpointing the moment in which this effect is largest could lead to more tailored interventions, possibly preventing people from experiencing strong cravings and, in turn, preventing relapse. The findings of the lagged analysis highlight the important role stress plays in AUD.

On the other hand, one very apparent limitation, already mentioned above, is the small sample size. Due to this, the power of the study is low, except for the within-person analyses,

and conclusions drawn based on the results should be taken with caution. Additionally, it makes it hard to generalize any of the findings to a larger population, indicating that all findings should be seen as trends rather than definite conclusions.

Another limitation already mentioned is the measure used to assess social support. As it has only been measured at baseline, the grouping of the participants may have unknowingly changed over time which might have led to a non-significant interaction term. As peer support groups for example count as social support, the participants scoring low on social support at the beginning of treatment may have gained social support by partaking in therapy. Peer support groups have been shown to be effective in reaching positive treatment outcomes (Connor et al., 2016; Tracy & Wallace, 2016). Thus, the level of social support should not only be measured at the start but be checked throughout the duration of the study in case of changes. The researchers also only made use of 9 of the 12 items, which leads to no information regarding the reliability and validity of the measure which, furthermore, is not a treatment- or addiction-specific measure. Future research should make use of tested, reliable assessments. If possible, measures specializing in social support surrounding psychological treatment or addiction could be of help, so that topics such as shame can be addressed, and the participants can indicate whether they would reach out for support in regard to their treatment and moments of craving, as an example. Furthermore, ruling out types of social circles which might also be involved in drinking or do not know of the participants problems is an important step in the setup of future studies regarding addiction treatment and social support. Moreover, sex and age of the four participants used in the current study are unknown and were not able to be incorporated in the current study. As previous research has shown, both factors play a significant role when researching social support. For example, Milner and colleagues (2016) found, in a longitudinal study, that women and people under the age of 30 appear to benefit most from high social support compared to older people and men regarding overall better mental health. Moreover, Reevy and Maslach (2001) reported that people with more feminine traits are more likely to look for and be given emotional social support. Thus, controlling for these variables may have led to differing results, and should be included when incorporating social support. Other possible confounding factors should also be included in future research and treatment. If social support truly does not have as big of a buffering effect as suspected, research needs to continue inspecting other possible protective factors to further improve treatment options. As has been shown previously, AUD is a complex disorder influenced by many factors worth investigating (see Clay et al., 2018, Gavurova et al., 2022, and Kuerbis et al., 2020 for examples). Moreover, age and gender have been shown to

correlate with social support (Milner et al., 2016; Reevy & Maslach, 2001), and thus should also be controlled for.

Lastly, a common difficulty in using EMA data are missing data points. Especially when looking at variables such as stress and craving, two negative experiences, it is reasonable to believe that high levels of both variables were not reported, as the participants were trying to deal with these emotions, not thinking about the study or about attending to their phones or may have been in states of intoxication. This might have led to relatively low levels of both stress and craving being reported at most time points, leading to less extreme variation, in form of low means and standard deviations. This, in turn, can lead to decreased statistical power and generalizability. These low levels of stress and craving might also be the case since the participants are already in treatment, which might reduce the ability to determine the true effects of social support, if present, because other factors such as self-efficiency may become more important. It also makes it more difficult to draw conclusions about addicted persons outside of treatment or new to treatment. Future research might benefit from starting data collection at the beginning of treatment. In addition, as previous research has found, studies consisting of dependent samples often show significantly lower compliance rates as samples consisting of non-dependent persons in EMA studies (Jones et al., 2019). As Shiffman (2009) reported, compliance varies a lot, and samples of people with AUD were found to record less around times of relapse.

### **Implications**

The above-mentioned results, strengths, and limitations hint at implications for future treatment. As the results of the single LMMs, the lagged analysis, and the graphs have shown, the relationship between stress and craving is present in the moment, but a predictive relationship also exists. This implies that treatment should focus on skills for the moments during which stress is present and high, to target the risk factor when it arises.

What the complexity of the disorder, as well as the findings in this current study, underline, is the importance of individualized treatments. As the results were driven by within-person factors and as the graphs highlight, the relationship between the two variables stress and craving, though always present, differs greatly in each person. The contexts in which stress and craving occur, the type of social support the person has, and the beliefs in one's own ability are all examples of possible confounding factors, possibly influencing the effects of social support.

### **Conclusion**

In conclusion, the relationship between stress and craving appears strong, regardless of



the level of perceived social support. Stress has been found to play a crucial role in cravings, with a predictive effect present. These findings are in line with past research. Future research should inspect the possible role of social support again, as well as other possible protective or confounding factors. For this, an ecological momentary assessment approach seems important, as it provides deeper insights into the relationship between highly fluctuating variables over the course of a prolonged period of time and in their natural contexts. A reliable measure of social support is necessary in order to inspect its possible buffering effect, which might exist but has not been able to be replicated in the present study due to multiple limitations, such as small sample size and baseline measurement. The findings hint at the importance of personalized treatment options, due to visible differences in the variables stress and craving as well as their relationship across patients.

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## Appendix

### ISLE-12 Questionnaire Items

The items were accessed through the Common-Cold Project website (Carnegie Mellon University, n.d.), which were adapted from Cohen et al. (1985).

Items 2, 3, 4, 5, 6, 7, 8, 10, and 11 were included. The participants were asked these questions in Dutch. The subscale is indicated in the brackets, as well as reverse code where applicable.

2: I feel that there is no one I can share my most private worries and fears with. (Appraisal; reverse coded)

3: If I were sick, I could easily find someone to help me with my daily chores. (Tangible)

4: There is someone I can turn to for advice about handling problems with my family. (Appraisal)

5: If I decide one afternoon that I would like to go to a movie that evening, I could easily find someone to go with me. (Belonging)

6: When I need suggestions on how to deal with a personal problem, I know someone I can turn to. (Appraisal)

7: I don't often get invited to do things with others. (Belonging; reverse coded)

8: If I had to go out of town for a few weeks, it would be difficult to find someone who would look after my house or apartment (pets, plants, garden, etc.). (Tangible; reverse coded)

10: If I was stranded 10 miles from home, there is someone I could call who would come and get me. (Tangible)

11: If a family crisis arose, it would be difficult to find someone who could give me good advice about how to handle it. (Appraisal; reverse coded)

Items not included:

1: If I want to go on a trip for a day (for example, to the country or mountains), I would have a hard time finding someone to go with. (Belonging; reverse coded)

9: If I wanted to have lunch with someone, I could easily find someone to join me. (Belonging)

12: If I needed some help in moving to a new house or apartment, I would have a hard time finding someone to help me. (Tangible, reverse coded)