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Technological Interventions for the Treatment of Substance Use Disorders

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Introduction

Substance use disorders (SUDs) are characterized as chronic relapsing disorders, characterized by compulsive seeking and consumption of a substance, and a diminished ability to control this behavior despite negative consequences. In the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), SUDs are classified on a severity scale based on the number of defining criteria, including using more or longer than intended, unable to cut down, or continuing use despite professional or social problems, or despite physiological or psychological problems. Mild SUD is characterized by fulfilling 2–3 criteria, moderate SUD is characterized by fulfilling 4–5 criteria and severe SUD is characterized by fulfilling $\geq$6 criteria. In contrast to previous editions of the DSM, craving was added to the fifth edition as a central component for the persistence of SUD, which replaced the legal problems criterion. Furthermore, the description of an SUD was further expanded with the inclusion of the brain reward system as a central component to the initiation and maintenance of SUDs (Nathan et al., 2016).

With a vast number of people diagnosed with an SUD, SUDs pose a major public health concern. Comprising 314 million people globally, the prevalence rate of SUDs has been estimated to be around 2.4% (WHO, 2018). Moreover, with approximately 21 million disability-adjusted life years lost yearly, SUDs have a significant societal and economic burden (Degenhardt et al., 2018). However, SUDs routinely start as substance use problems in the form of substance misuse. Using any substance at high amounts or in inappropriate settings can lead to health and social problems, which is called substance misuse. In fact, globally about 16.0% of drinkers engage in problem drinking, including binge drinking. It is estimated that annually 275 million individuals use illicit drugs, which translates into an annual prevalence rate of illicit drug use of 5.6% (WHO, 2018). Therefore, the identification and early intervention by means of substance use reduction interventions in individuals who misuse substances, is an important to effectively reduce the burden of substance misuse and SUDs.

Over the years, many evidence-based psychotherapeutic treatments have been developed, including cognitive behavioral therapy (CBT), motivational interviewing (MI) and the community reinforcement approach (CRA). These interventions can potentially be delivered in different approaches, for example as a single session intervention based on a single therapeutic principle or as a combination of multiple principles applied in multiple sessions. Single session interventions commonly consist of brief interventions, personalized normative feedback or motivational interviewing, and are typically designed to target non-clinical populations of alcohol and cannabis users. Multiple reviews and meta-analyses have indicated the effectiveness of brief interventions in the reduction of alcohol use (e.g., Kaner et al., 2018; O'Donnell et al., 2014; Schmidt et al., 2016) and cannabis use (e.g., Halladay et al., 2019), as well as for personalized feedback (e.g., Miller et al., 2013; Walters and Neighbors, 2005) and motivational interviewing (DiClemente et al., 2017). On the other hand, interventions containing multiple sessions often apply cognitive behavioral therapy (CBT), motivational interviewing (MI), community reinforcement approach (CRA), ecological momentary assessment (EMA), or a combination of several principles in "integrated therapeutic principles", and are more commonly applied in more severe cases of substance use, including illicit substances. Several reviews and meta-analyses have indicated the effectiveness of different therapeutic principles in the reduction of substance use, including CBT (e.g., Magill et al., 2019), MI (e.g., DiClemente et al., 2017), CRA (e.g., Roozen et al., 2004), and EMA (Clifford and Davis, 2012).

However, depending on the primary substance of choice, only approximately 7.5%–20% of people with an SUD make use of any treatment service (Lipari et al., 2016; Saloner and Karthikeyan, 2015; Schmidt, 2016). The low use of and poor adherence to traditional treatment strategies can be explained by several factors, including stigma, acces to treatment services, forced abstinence as a goal, or time conflicts between participating in treatment and other obligations (CBHSQ, 2018; Xu et al., 2008). The influence of these factors appear to be similar for people of different age, gender and ethnicity with regard to treatment seeking (Xu et al., 2008).

Obstacles to treatment utilization could potentially be overcome by the employment of digital interventions, commonly referred to as e-health interventions. E-health interventions can be defined by the use of information and communication technologies to deliver healthcare, including telephones, computers and the internet. E-health interventions potentially lower the threshold to treatment access, increase perceived anonymity during treatment, and increase the availability of treatment independent of time and place (Riper et al., 2010; Taylor and Luce, 2003). Based on several meta-analyses (e.g., Boumparis et al., 2019; Boumparis et al., 2017; Riper et al., 2018), it has been suggested that digital substance use reduction interventions display promising results for a variety of target groups. The evidence on effectiveness appeared strongest for digital interventions targeting alcohol use (Kaner et al., 2017; Riper et al., 2018), followed by cannabis (Boumparis et al., 2019; Hoch et al., 2016) and illicit substances (Boumparis et al., 2017).

This chapter discusses the literature on technological interventions for the reduction of substance use in subclinical populations as well as individuals with an SUD. The term "technological interventions" is used to refer both to digital (e.g., computer- and internet-based) interventions, as well as telephone-based interventions (e.g., calls and text messages). First, traditional psychotherapeutic interventions will be discussed, such as CBT and MI. Second, their effectiveness in the treatment of substance use, ranging from excessive use to an SUD, will be discussed, with a focus on RCTs. Additionally, as there is high comorbidity between substance use and other psychiatric disorder (Grant et al., 2016; Saha et al., 2018), which has been shown to be associated with greater symptom severity, higher levels of disability, and worse treatment outcomes relative to individuals with non-comorbid conditions (McHugh, 2015; Quello et al., 2005; Riper et al., 2014), the effectiveness of interventions targeting substance use concurrently with other psychiatric disorders are also discussed. Digitally delivered standardized interventions were included, whereas more experimental approaches, such as cognitive bias modification and cognitive skills training were excluded as these are substantially different from psychotherapeutic treatments. In addition, only studies focusing on adult substance users are discussed, whereas studies focusing solely on university students are not included since these interventions have special characteristics that are tailored to this target group and are therefore not representative for the interventions targeting a wider audience of substance users. Finally, directions for future research and clinical implications of technological interventions for the treatment of SUDs will be discussed.

Effectiveness of Digital Interventions for the Treatment of SUDs

In recent years, e-health interventions have emerged and gained wide popularity in a variety of prevention and treatment settings. Several approaches exist within e-health interventions. For example, e-health interventions can be delivered as a standalone intervention, in which only the digital intervention is provided, or as an add-on, in which the digital intervention is added to a different digital or face-to-face intervention, such as treatment as usual or CBT. E-health interventions can be delivered unguided, i.e., the patient uses the intervention independently without any support from a professional, or guided, in which the patient receives some level of support from a trained professional while following the intervention. Guidance can take the form of chat-sessions or brief face-to-face monitoring sessions with a trained therapist.

E-health interventions encompass a wide variety of advantages depending on the chosen delivery format. These advantages include increased dissemination of information to individuals who would otherwise not seek support and treatment because of various barriers including economic problems, perceived stigma, transportation or other obstacles that might limit access to traditional treatments, increased insights of therapists into the individuals' disease trajectory, possible cost-effectiveness, decreased therapist time since e-health is especially well-suited to replace psychoeducation sessions and improve symptom monitoring (Darvell et al., 2015). For example, in digital CBT interventions, patients are exposed to identical components as in conventional face-to-face

CBT. Patients are asked to log in regularly to an internet-based treatment platform to access, read and download online materials and to complete specific modules in time (Kadden et al., 2003).

Digital interventions have shown effectiveness in a wide array of mental disorders, including SUDs. For example, a recent individual patient data meta-analysis of Riper et al. (2018) who included 14.198 adult participants from 19 RCTs based on therapeutic principles including PNF, CBT, MI or a combination thereof, found that digital alcohol interventions in both community and healthcare populations were effective in reducing mean weekly alcohol consumption and in achieving adherence to low-risk drinking limits compared to a control condition including assessment only, waitlists or minimal interventions. Furthermore, guided interventions seemed to have a larger treatment effect compared to unguided interventions. In addition, Boumparis et al. (2019) found in their meta-analysis that included 3813 cannabis users from 17 RCTs, that cannabis use reduction interventions produced a small but significant effect compared to controls at post-treatment. However, at long-term follow-ups, the effects were no longer statistically significant.

Finally, a meta-analysis on digital interventions for illicit substances (Boumparis et al., 2017) included 2836 adult participants from 17 RCTS. It was reported that digital opioid reduction interventions and polysubstance user interventions were significantly more effective than the control comparisons. In contrast, digital interventions on stimulant users were not significantly more effective than the control comparisons. However, given the small number of available interventions, especially for stimulant use reduction, we should see those outcomes as preliminary and encourage more high quality RCTs being conducted in order to reach more definite conclusions.

The next sections focus on literature investigating the effectiveness of technologically delivered psychotherapeutic interventions with the aim to reduce substance use in a variety of substances, including alcohol (see **Table 1**), cannabis, cocaine, amphetamine-type stimulants, and polysubstance use (see **Table 2**). For the sake of clarity, a distinction is made between brief single-session interventions and multiple-session intervention.

Table 1 Randomized controlled trials of technological interventions targeting alcohol use reduction

Study	*Setting*	*Total N*	*Intervention*	*Control*	*Mode of delivery*
Bertholet et al., 2015	Community	737	BI-ITP	AO	Internet
Bertholet et al., 2018	Community	737	BI-ITP	AO	Internet
Bertholet et al., 2019	Community	977	BI-ITP	AO	Smartphone
Bischof et al., 2008	Clinical - GP	408	ITP	Health education	Internet
Blankers et al., 2011	Clinical - SATC	205	ITP	WLC	Internet
Boon et al., 2011	Community	450	BI-PNF	Alcohol leaflet	Internet
Boß et al., 2018	Workplace	434	ITP	WLC	Internet
Brendryen et al., 2014	Community	244	ITP	PNF/e-booklet	Internet
Brendryen et al., 2017	Workplace	85	ITP	PNF/e-booklet	Internet
Cunningham et al., 2009	Community	185	BI-PNF	Alcohol leaflet	Internet
Cunningham et al., 2017	Community	423	BI-PNF	WLC	Internet
Cunningham, 2019	Community	3741	BI-PNF	AO	Internet
Cunningham et al., 2020	Community	282	ITP	CBT	Internet
Deady et al., 2016	Community	104	ITP	Attention control	Internet
Delrahim-Howlett et al., 2011	Clinical – maternity care	150	BI-PNF	Psychoeducation	Internet
Doumas and Hannah 2008	Workplace	196	BI-PNF	PNF + MI	Internet
Fernandez et al., 2019	Clinical - ED	750	BI-ITP	FTF BI, AO	Internet
Hester et al., 2005	Community	61	BI-ITP	WLC	Computer
Kay-Lambkin et al., 2011	Clinical – miscellaneous	274	ITP	FTF CBT + MI, therapist counseling	Computer
Khadjesari et al., 2014	Workplace	1330	BI-PNF	AO	Internet
Kiluk et al., 2016	Clinical – outpatient facility	68	CBT	TAU, CBT	Computer
Ondersma et al., 2015	Clinical – maternity care	48	BI-ITP	AO	Internet
Ondersma et al., 2016	Clinical – maternity care	123	BI-ITP	AO	Computer
Pemberton et al., 2011	Community	3070	BI-ITP	AO	Internet
Postel et al., 2010	Community	156	ITP	WLC	Internet
Riper et al., 2008	Community	261	ITP	Alcohol leaflet	Internet
Schulz et al., 2013	Community	498	PNF	AO	Internet
Sinadinovic et al., 2014	Community	633	ITP	AO	Internet
Suffoletto et al., 2014	Clinical - ED	45	PNF	AO	SMS
Sundström et al., 2016	Community	80	Guided iCBT	Unguided iCBT	Internet
Tzilos et al., 2011	Clinical – maternity care	50	BI-ITP	AO	Computer
Wallace et al., 2011	Community	7935	BI-ITP	Psychoeducation	Internet
Wallace et al., 2017	Clinical - GP	763	BI-ITP	FTF BI-MI	Internet

AO, Assessment Only; BI, Brief Interventions; CBT, Cognitive Behavioral Therapy; ED, Emergency Department; FTF, Face to Face; GP, General Practitioner; iCBT, internet-based CBT; ITP, Integrated Therapeutic Principles; MI, Motivational Interviewing; PNF, Personalized Normative Feedback; SATC, Substance Abuse Treatment Center; SMS, Short Message Service; TAU, Treatment as Usual; WLC, Waitlist Control.

Table 2 Randomized controlled trials of technological interventions targeting cannabis, opioid, amphetamine-type stimulants, cocaine and poly-substance use reduction

Study	*Setting*	*Total N*	*Intervention*	*Control*	*Mode of delivery*	*Effectiveness*
Cannabis						
Becker et al., 2014	Community	325	BI-PNF, BI-MI	Psychoeducation	Internet	8W:N
Budney et al., 2015	Clinical	75	ITP	MI	Computer	12W: Y
Jonas et al., 2012	Community	302	BI-MI	Psychoeducation	Online chat	1M: N 3M: N
Jonas et al., 2019	Community	534	28-day ITP 28-day ITP + chat-based MI 50-day ITP 50-day ITP + chat-based MI	N/A	Internet	3M: Y (all groups) 6M: Y (all groups) 12M: Y (all groups)
Rooke, 2011	Community	230	ITP	Psychoeducation	Internet	6W: Y 6M: Y
Schaub et al., 2015	Community	308	ITP	WLC	Internet	3M: Y
Tossman et al., 2011	Community	1292	ITP	WLC	Internet	3M: Y
Opioids						
Bickel et al., 2008	Community	135	BI-CRA	FTF CRA	Computer	23W: Y
Chopra et al., 2009	Community	120	BI-CRA	FTF counseling	Computer	3M: N
Christensen et al., 2014	Community	170	BI-CRA	CM	Computer	3M: Y
Marsch et al., 2014	Clinical – outpatient clinic	160	BI-CRA	TAU	Computer	12W: Y
Amphetamine-type stimulants						
Reback et al., 2018	Clinical – outpatient facility	34	EMA with guidance EMA without guidance	N/A	Smartphone	8W: N
Tait et al., 2014	Community	160	CBT	WLC	Internet	3M: N
Cocaine						
Brooks et al., 2010	Clinical – outpatient clinic	26	ITP + CM	TAU + CM	Computer	8W: N
Carroll et al., 2014	Clinical – outpatient clinic	101	CBT	TAU	Computer	8W: Y 6M: Y
Schaub et al., 2012	Community	196	CBT	Psychoeducation	Internet	4W: N 6W: N 6M: N
Schaub et al., 2019	Community	416	ITP	WLC	Internet	6W: N
Polysubstance						
Acosta et al., 2017	Clinical – veteran affairs primary care	162	CBT + TAU	TAU	Internet	12W: Y
Aharonovich et al., 2017	Clinical – HIV primary care	42	ITP	MI	Smartphone	2M: Y
Blow et al., 2017	Clinical - ED	780	BI unguided BI computer guided	TAU	Computer	12M: N
Braciszewski et al., 2018	Foster care	33	BI + MI	Attention control	Smartphone	12M: Y
Campbell et al., 2014	Clinical – outpatient clinic	507	CRA + CM	TAU	Computer	12W: Y
Carroll et al., 2008	Clinical – outpatient clinic	92	CBT + TAU	TAU	Computer	8W: Y
Drislane et al., 2020	Clinical - ED	780	BI + MI	FTF BI + MI TAU	Computer	N
Gryczynski et al., 2016	Clinical – community health center	80	BI	WLC	Computer	3M: N 6M: N
Kiluk et al., 2018	Clinical – mental health center	137	CBT	FTF CBT TAU	Computer	12W: N 6M: Y vs TAU
Ondersma et al., 2007	Clinical – maternity care	107	BI + MI	AO	Computer	4M: Y
Ondersma et al., 2014	Clinical – maternity care	143	BI + MI	AO	Computer	3M: Y 6M: Y
Paris et al., 2018	Clinical – outpatient facility	92	CBT + TAU	TAU	Computer	8W:Y
Schwartz et al., 2014	Clinical – community health center	359	BI	FTF BI	Computer	3M: N

AO, Assessment Only; BI, Brief Interventions; CBT, Cognitive Behavioral Therapy; CM, Contingency Management; CRA, Community Reinforcement Approach; ED, Emergency Department; EMA, Ecological Momentary Assessment; FTF, Face to Face; N/A, Not Applicable; ITP, Integrated Therapeutic Principles; MI, Motivational Interviewing; PNF, Personalized Normative Feedback; TAU, Treatment as Usual; WLC, Waitlist Control

Alcohol

Single-session Interventions

Personalized Normative Feedback

Personalized Normative Feedback (PNF) interventions are usually unguided and consist of a brief single session lasting typically 15–30 min. The aforementioned individual patient data meta-analysis (IPDMA) comprising 14.198 participants from 19 RCTs investigated the effectiveness of internet-based interventions for adult problem drinking (Riper et al., 2018). Although both men and women of different age groups, drinking profiles and settings appeared to benefit from these internet-based interventions, it appeared that PNF-only interventions were less effective compared to interventions applying integrated therapeutic principles. Although the overall results appear to be positive, the results of the individual studies can vary based on setting, target group and follow-up period.

For example, in a community setting, Boon et al. (2011) investigated the effectiveness of an unguided single session PNF intervention in 450 heavy drinking men (>20 units/week and/or >5 units/occasion). After 1 month, more participants from the experimental group reduced their alcohol consumption below the threshold compared to participants in the control group receiving information only. However, this effect was no longer significant at 6-months follow-up. In a different study, the effectiveness of an unguided single PNF session was investigated in different target groups from the general population (Cunningham et al., 2009). To this end, 185 risky drinkers (AUDIT-C≥4) were recruited and, based on the full AUDIT, divided into problem drinkers (AUDIT≥11) and low-risk drinkers (AUDIT score of 4–10). Significant reductions in drinking behavior were found at 3-month post-intervention, as well as at 6 months follow-up, but only in problem drinkers and not in low-risk drinkers or the control group who received information only. A more recent study by Cunningham et al. (2017) investigated the feasibility of using Amazon's Mechanical Turk (MTurk) to recruit problem drinkers (AUDIT>8) from the general population for a single unguided PNF session. Amazon's MTurk is an online platform that offers registered individuals who are paid to perform certain online tasks, such as surveys. Although recruitment was highly successful (423 participants in 3.2 h), no significant between-group differences in the number drinks per week were found at 3-month follow-up. The lack of between-group differences could be explained by a floor effect, since, despite meeting the criteria for problem drinking at baseline, participants reported to drink less than 15 drinks per week. The motivation of participating in such an online endeavor could be considered dubious, as participants probably participated for the monetary compensation. However, such massive online recruitment methods could be beneficial for quick evaluations of intervention components.

In a workplace setting, Doumas and Hannah (2008) investigated the effectiveness of an unguided single-session PNF intervention in 196 young adult employees (18–24 y/o). There were no eligibility criteria regarding alcohol consumption, but 31% was classified as high-risk drinkers (>4/5 drinks in a row in the past 2 weeks for females/males) and 69% as low-risk drinkers. Significant lower drinking levels were reported at the 1-month assessment in the intervention group compared to the control group, with greater effects for high-risk drinkers compared to low-risk drinkers. A more recent study also investigated the effect of an unguided single PNF session in the workplace community (Khadjesari et al., 2014), incorporating feedback on alcohol consumption, BMI, smoking status, fruit and vegetable consumption and level of physical activity. To this end, 1330 employees who reported alcohol misuse (AUDIT-C≥5) were included. After 3 months, there were no differences between the intervention group and the control group with respect to past week drinking, alcohol-related harm as measured with the AUDIT questionnaire, or health utility as measured with EQ5D questionnaire. However, as the groups are only compared at 3-month follow-up, it could be that a similar decrease between both groups has gone unnoticed. This would indicate that unguided single PNF sessions targeting multiple health aspects are also sufficient to (indirectly) affect drinking behavior, even without specifically targeting alcohol consumption as one of the aspects.

Unguided single-session PNF interventions have also been investigated in clinical settings, including maternity clinics and emergency departments. For example, Delrahim-Howlett et al. (2011) investigated the effect of an internet-based single PNF session in 150 risky drinking (>3 drinks per occasion) women with the desire of pregnancy (Delrahim-Howlett et al., 2011). At 1-month and 2-month follow-up, the intervention group did not show greater reductions regarding risky drinking, as defined as more than three drinks per occassion, number of drinks or reduction in number of drinks compared to the control group receiving information on general and risk-related risks of alcohol use. Non-significant effects were also reported by another study that investigated the effectiveness of a computerized single PNF session in hazardous drinkers ($n = 837$, AUDIT-C>5), who were recruited at the hospital emergency department.

Integrated Therapeutic Principles

As interventions based on integrated therapeutic principles contain at least two principles, they can be considered more extensive compared to a single-session PNF intervention. A meta-analysis on the effectiveness of digital interventions targeting adult problem drinking in the community that included 19 RCTs with a total of 1553 participants, reported that extended interventions were found to be more effective compared to single-session PNF interventions ($g = 0.61$ vs $g = 0.27$, respectively; Riper et al., 2011). This difference in effectiveness was also reported in the later IPDMA on the effectiveness of internet-based interventions for adult problem drinking (Riper et al., 2018). However, when looking at individual studies, the effectiveness of applying a combination of several therapeutic principles in a variety of target groups and settings can vary depending on factors such as setting, target group and follow up period.

Different combinations of integrated therapeutic principles have been investigated in the community setting. For example, Bertholet et al. (2015) investigated the effectiveness of an internet-based unguided single session containing PNF as well as feedback on different aspects, including consequences of alcohol use, caloric value, blood alcohol concentration, risk, health and recommendations for lowering risk in adult men with unhealthy alcohol use (>14 drinks/week or ≥6 drinks/occasion or AUDIT≥8). Compared to the assessment only control group, the intervention group showed a greater reduction in drinks/week after one and after 6 months. However, no such effect appeared with respect to binge drinking prevalence. As the participants were part of an ongoing cohort, this allowed to investigate the effects of the intervention at 4-year follow-up (Bertholet et al., 2018). Although both groups showed significant reductions in monthly or more binge drinking prevalence at 4-year follow-up, there were no significant between-group differences at this long-term follow-up assessment. This might indicate that BIs might not be effective to reduce drinking over the long-term and that additional BIs might be needed to maintain beneficial effects. Based on the latter two studies (Bertholet et al., 2015, 2018), Bertholet et al. (2019) investigated the effectiveness of a smartphone application to reduce unhealthy drinking in 977 unhealthy drinkers (AUDIT≥8 and ≥15 drinks/week). The smartphone application contained various modules including PNF and self-monitoring. At 6-month follow-up, there were no intervention effects with respect to drinking frequency (i.e., drinks per week), but there appeared to be a significant intervention effect on volume (i.e., number of drinks per occasion). However, the results were only significant based on per protocol analysis and not significant based on intention to treat (ITT) analysis, questioning the robustness of the results. Other combinations of therapeutic principles to target alcohol use in BIs have also been investigated in the community setting. For example, Hester et al. (2005) studied the effect of a BI including MI, PNF, and behavioral self-control in 61 problem drinkers (AUDIT≥8). Compared to the 4-week waitlist control group, the intervention group did significantly reduce their drinking, which was sustained at 12-month follow-up. A later study used the same intervention, but adapted it to be suitable to use for U.S. military personnel (Pemberton et al., 2011), reported significant reductions in drinking behavior in the intervention group compared to the control group receiving assessment only at 1-month and 6-month follow-up. Another study, investigating the effectiveness of an internet-based BI comprising CBT, MI and BSC, included 7935 participants who met the criteria for hazardous drinking (AUDIT-C≥5; Wallace et al., 2011). At both 3-month and 12-month follow-up, there were no differences between the intervention group and the control group that was referred to unguided non-interactive web psychoeducation.

Also in a clinical setting, there are several studies investigating the effectiveness of different combinations of therapeutic principles. For example, in a series of pilot studies, computer-based BIs containing components of PNF and MI were investigated in problematic drinking pregnant or postpartum women during a visit in the hospital or prenatal clinic, respectively (Ondersma et al., 2015; Ondersma et al., 2016; Tzilos et al., 2011). All three studies tailored the intervention to the target group, used a single unguided session, and compared the results to an assessment only control group. Even when the intervention was expanded with an in-person follow-up, tailored videos and subsequent tailored mailings, none of the studies reported significant between-group differences in alcohol consumption at 1-month (Tzilos et al., 2011) or 3-months (Ondersma et al., 2015, 2016) post-treatment follow-up. As all three studies were pilot RCTs, the non-significant results could be attributed to a lack of power. A recent study by Fernandez et al. (2019) investigated the effect of a computer-delivered BI composed of MI and PNF, as well as protective behavioral strategies (PBS) in 750 participants recruited from the hospital ED who met the criteria for alcohol misuse (AUDIT-C≥3/4 for women/men). After 12 months, the groups receiving FTF BI or computerized BI did not differ from the control group receiving assessment only. All groups showed significant decreases in alcohol consumption at 12-month follow-up. However, the effects of computerized BI on drinking behavior compared to AO appeared to be moderated by age, in that the effects of computerized BI were greater in younger (i.e., 21–35 years-old) participants compared to older participants (36–65 years-old). In a primary care setting, the effectiveness of an internet-based BI comprising CBT, MI and BSC was investigated in 763 potentially hazardous drinkers (AUDIT-C≥3/4 for women/men; Wallace et al., 2017). Compared to the GP-delivered FTF BI based on MI, there was a significant greater reduction (10%) in the number of patients with a score ≥8 on the full AUDIT questionnaire at 12-month follow-up. Remarkably, the control group receiving FTF BI showed a 15% increase in the number of people with an AUDIT score ≥8. However, as the authors pointed out, the final question of the AUDIT questionnaire might have caused bias in the results. As the question asks whether participants received advice to reduce drinking from a healthcare professional, it is likely that participants in the control condition answered this question positively due to the FTF contact with a professional.

Multi-session Interventions

In contrast to the brief single-session interventions, more extensive multi-session interventions have also been developed. Although they can comprise a single-focus or multiple therapeutic principles, they are usually applied to individuals suffering from more severe and/or prolonged substance use. Additionally, these interventions can be delivered as add-on or standalone interventions. In addition, although guided as well as unguided studies have been investigated, the alcohol field has predominantly focused on unguided interventions.

Single-focus Therapeutic Principles

Personalized Normative Feedback

Although PNF interventions are usually unguided and consist of a brief single session lasting typically 15–30 min, some studies have also investigated more extensive PNF interventions to target alcohol use. As mentioned earlier, compared to single-session PNF interventions, more extensive interventions did appear to be more effective (Riper et al., 2011, 2018). Although the overall results appear to be positive, the results of the individual studies can vary based on setting, target group and follow-up period.

For example, Schulz et al. (2013) investigated the effectiveness of a 3-session PNF intervention delivered through the internet and compared two different feedback strategies (alternating vs. summative) in a community setting. To this end, 448 unhealthy drinkers as defined by drinking more than German guideline (>1 glass (women) or >2 glasses (men) per day, >5 glasses per week, and AUDIT>7) were included. With respect to complying to the German drinking guidelines at 6-month follow-up, the results were only significant in the complete case analysis and not significant based on ITT analysis, questioning the robustness of the results. However, there were no significant between-group differences regarding the number of drinks per week, with either complete case analysis or ITT analysis. Additionally, there were no differences between the group who received alternating feedback compared the group who received summative feedback. A different study investigated the effectiveness of an extensive PNF study in a clinical setting. In a 12-week study, Suffoletto et al. (2014) investigated the effectiveness of a PNF intervention delivered via mobile phone text messages in 765 young adult hazardous drinkers (AUDIT-C≥3/4 for women/men) who were recruited from the emergency department. Drinking behavior was measured through web-based assessments at baseline and 3-month follow-up, as well as through SMS assessments during the intervention in order to generate feedback. Compared to assessment only through SMS and/or web-based questionnaires, bi-weekly real-time feedback resulted in decreased self-reported binge drinking days and number of drinks per drinking day. This effect appeared from both the SMS assessments as well as from the web-based assessment.

Cognitive Behavioral Therapy

The effectiveness of an eight-module internet-based CBT intervention was investigated in 80 problem drinkers (AUDIT≥6/8 for women/men) from the general population (Sundström et al., 2016). All participants received the intervention, but two groups received additional guidance. One group received guidance via asynchronous text messages only, whereas the other group could choose between asynchronous text messages or synchronous text-based chat. At 10-weeks follow-up, the groups who received guidance showed a significantly greater reduction in alcohol use and lower AUDIT-scores compared to the group who did not receive guidance. Differences in intervention effects between guidance groups were not analyzed, but based on the choices from the group who could choose participants favored asynchronous text messages (68%) over synchronous text-based chat (35%).

A different study has investigated the effectiveness of a web-based CBT intervention in a clinical setting. Kiluk et al. (2016) investigated the effect of computer-based CBT in 68 treatment-seeking individuals with an AUD (based on DSM-IV criteria for alcohol abuse or dependence). In the experimental groups, the computerized CBT was combined with psychotherapy as TAU or combined with weekly brief monitoring. Compared to the control condition of TAU-only, computer-based CBT in combination with TAU produced a significantly greater percentage of abstinent days ($d = 0.71$) up to 6-month follow-up. Additionally, clinical monitoring did not have an additional effect to computer-based CBT. Thus, computer-based CBT delivered as add-on to TAU might be valuable for patients with AUD in outpatient addiction facilities.

Integrated Therapeutic Principles

As previously mentioned, more extensive interventions appeared to be more effective compared to single-session PNF interventions (Riper et al., 2011, 2018). As more extensive interventions are also more often guided by a professional, several studies have also investigated the effectiveness of guided studies. Although guided as well as unguided studies appear to be effective, guided interventions appeared to have a larger treatment effect compared to unguided interventions (Riper et al., 2018). However, when looking at individual studies, the effectiveness of applying a combination of several therapeutic principles can vary depending on factors such as setting, target group and follow up period.

Several studies have investigated the effect of multi-session interventions based on some combination of therapeutic principles. For example, in one of the first unguided internet-based intervention in a community setting (Riper et al., 2008), investigated the effectiveness of an intervention combining CBT and MI in 261 problem drinkers as defined as exceeding the Dutch guideline for low-risk drinking (14/21 units peer week or ≥4/6 for women/men at least once a week for the past 3 months). Compared to a psychoeducational brochure on alcohol use, the intervention group showed a greater proportion of participants who reduced their drinking to within the guideline and a greater decrease in mean weekly drinks at 6-month follow-up. A different study that took place in the community setting investigated the effectiveness of an unguided, internet-based intensive intervention containing CBT and BSC added to a brief PNF intervention compared to a control group receiving the same brief PNF intervention as well as an information booklet on the effects of alcohol use (Brendryen et al., 2014). To this end, 244 at risk drinkers (Fast Alcohol Screening Test [FAST] ≥3) were recruited. The results partially indicated greater effects for the intensive intervention, depending on factors including statistical analyses and follow-up time. Specifically, at 2-month follow-up, there were between-group differences in self-reported alcohol use when the data was analyzed using complete cases analyses, but not with intention-to-treat analyses, questioning the robustness of the results. Interestingly, at 6-month follow-up, both analysis strategies resulted in significant between-group differences, which was attributed to the study being too underpowered to detect true effects. In another unguided, internet-based approach, Sinadinovic et al. (2014) compared a BI containing PNF and MI components, a more extensive CBT and MI-based self-help intervention and an assessment only control group. To this end, 633 hazardous drinkers (AUDIT≥6/8 for women/men) were recruited from the community. All three groups showed reduction in alcohol use at 3-month follow-up, which was maintained until the 12-month follow-up. Although the more extensive self-help intervention appeared to be more effective at 6-month and 12-month, this was especially the case when additional interventions were accessed, questioning the effectiveness of the intervention under study. Although most studies have investigated unguided interventions, some have focused on guided interventions in a community setting. One such study investigated the effectiveness of a guided, internet-based intervention based on

CBT and MI principles to reduce alcohol consumption in 156 problem drinkers (>15/22 units/week and <67/99 units/week for men/women) recruited from the community (Postel et al., 2010). Compared to a waitlist control group, there was a large effect on alcohol consumption in the intervention group at 3-month follow-up. Furthermore, more people in the intervention group reduced their drinking to under the problem drinking limit compared to the control group. In addition, the reasons for dropout were also investigated in this study. Of the 156 participants that were initially recruited, 42 participants from the intervention group completed an average of 5.1/12 assessments and did not complete post-treatment assessment. Several reasons were provided to account for dropping out of the study, including reasons unrelated to the intervention, discomfort with the treatment protocol and already achieving the expected results of reduced alcohol consumption. Future studies could benefit from investigating reasons for poor adherence or even dropout.

Given the high comorbidity of alcohol use and other mental disorders such as depression (Boschloo et al., 2011) and problematic gambling (Petry et al., 2005), it is important to assess technological interventions targeting individuals who suffer from both conditions concurrently. For example, Deady et al. (2016) investigated the effectiveness of a transdiagnostic intervention consisting of web-based CBT and MI compared to a health information attention control condition. To this end, 104 young adult problem drinkers (AUDIT≥8) with moderate depression (Depression Anxiety Stress Scale [DASS] ≥7) were recruited from the community. At 3-month follow-up, the Intervention group showed a statistically significant improvement in depression symptom severity and reduction in alcohol use compared to the health information attention control group. However, at 6-month follow-up, the improvements in depressive symptoms and alcohol use were no longer significantly different between the two groups. Given the observed low adherence and high attrition of the study, further high-quality RCTs are required to better understand transdiagnostic interventions targeting alcohol use and depressive symptoms concurrently and how to improve long-term outcomes. In a more recent study by Cunningham et al. (2020) recruited 282 problem gamblers (Problem Gambling Severity Index ≥3), of which 41% showed unhealthy alcohol use (AUDIT≥8). It should be noted that alcohol use was not mentioned during the recruitment process. Participants were randomized into a 4-module unguided online CBT-based gambling-only intervention, or into the identical 4-module unguided online CBT-based gambling-only intervention plus a single-session PNF module targeting alcohol use. The results show no between-group differences in gambling at 3-month or 6-month follow-up. In addition, in the sub-sample showing problematic alcohol use, there were no between-group differences in reductions in alcohol consumption.

Multi-session interventions based on integrated therapeutic principles have also been investigated in the workplace setting. For example, in a pilot RCT, for which 85 hazardous drinkers (FAST≥3) were recruited, the effectiveness of an unguided internet-based intervention containing CBT, BSC and PNF was compared to control group also receiving PNF in addition to an information booklet on the effects of alcohol use (Brendryen et al., 2017). At 2-month follow up the results were similar to their former study. That is, the complete cases analysis showed significant between-group differences, but the intention-to-treat analysis did not, questioning the robustness of the results. However, in contrast to the former study, there were no significant between-group differences in drinks per week at 6-months follow-up, regardless of analytic approach. In another study, Boß et al. (2018) have investigated the effectiveness of a web-based intervention comprising PNF, MI and behavioral activation (BA) in a group of 434 risky drinkers (AUDIT score ≥6/8 + 14/21 units/week for women/men) recruited from a workplace setting. Additionally, it was investigated if adding adherence focused guidance would be beneficial to the outcome measures. After 6 weeks, both interventions groups (i.e., with and without guidance) showed a similar decrease in weekly units of alcohol compared the waitlist control group. However, the added guidance did not appear to have an additional effect, as was revealed by the absence of a significant difference between the intervention groups. These effects were retained at the 6-months follow-up assessment, indicating potentially long-term effects of the intervention.

In a clinical setting, Bischof et al. (2008) investigated the effect of how guidance was delivered and included 480 GP patients who met criteria for alcohol dependence or abuse (based on the Composite International Diagnostic Interview [CIDI]), at-risk consumption (>20/30g day^{-1} for women/men within last 4 weeks), or binge drinking (>60/80 g on at least 2 occasions within last 4 weeks). Both intervention groups received computerized feedback on their drinking behavior assessed at baseline and brief counseling sessions based on MI principles. For one group, these counseling sessions took place after one, three, and 6 months, whereas the other group received all brief counseling session simultaneously to the computerized feedback, as well as after one, three and 6 months later. Compared to an assessment-only control group, both intervention groups showed a reduction in drinking behavior, but only for the sub-sample who met the criteria of abuse or at-risk drinking. However, participants who were allocated to receive multiple counseling received around 50% of the counseling sessions compared to participants who received counseling sessions simultaneously to the feedback, indicating increased cost-effectiveness of a stepped care approach. Another study compared the effectiveness of internet-based intervention based on MI and CBT techniques with a waitlist control group in 205 problematic alcohol users (AUDIT≥8 and >14 units/week) recruited through the website of an substance abuse treatment center (Blankers et al., 2011). Moreover, it was investigated if there was a difference in effectiveness when the intervention was delivered as a guided or as an unguided intervention. Three months post-randomization, both the guided as well as the unguided intervention showed greater reductions on alcohol consumption compared to the control group. Additionally, there were no difference between the guided and unguided intervention groups. Interestingly, the effects obtained for the guided intervention were larger compared to the unguided intervention at 6 months post-randomization. This suggests that although both guided and unguided interventions could lead to significant reductions in alcohol use, the effects of guided interventions might be retained long-term.

Transdiagnostic interventions to treat comorbid alcohol problems and depression have also been conducted in a clinical setting. For example, Kay-Lambkin et al. (2011) recruited 274 individuals who indicated harmful drinking patterns in the past month and scored ≥17 on the BDI-II. The participants were randomized into (a) 9-week guided computer-based CBT + MI intervention plus

weekly 10 min brief FTF monitoring, (b) a 9-week FTF CBT + MI intervention, or (c) person-centered therapy. At 3-month follow-up, the computer-based CBT and FTF-delivered CBT were significantly more effective in reducing depressive symptoms and alcohol reduction compared to person-centered therapy. The computer-based CBT condition was associated with improvement at least equivalent to that achieved by FTF-delivered CBT and was outperforming it as far as reducing alcohol consumption in patients was concerned. In addition, change in depressive symptoms was bidirectionally predicted by change in alcohol use.

Summary on Technological Interventions Targeting Excessive Alcohol Use

Studies on the effectiveness of technological interventions for the treatment of excessive alcohol use have investigated single-session as well as multi-session approaches based on a single therapeutic principle or integrated therapeutic principles, targeting community, clinical and workplace settings. Follow-up periods generally ranged from 1 month to 1 year and the internet was mostly used as delivery mode. Single-session PNF interventions appear to be effective for both men and women of different age groups, drinking profiles and settings. The presented studies focused on different settings, including the community setting, workplace setting and clinical settings. The results were ambiguous, with significant as well as non-significant effects of the intervention. Moreover, the results tended to be significant for specific sub-groups of heavier drinkers and to have tapered off at long-term follow-up. Applying multiple PNF sessions did not appear to affect the ambiguity in the results. Compared to PNF-based interventions, interventions based on integrated therapeutic principles appear to be more effective. However, the presented studies showed ambiguity with respect to the effectiveness of the interventions under investigation, regardless of setting, follow-up period or mode of delivery. Furthermore, the presented multi-session interventions were based on just CBT or on integrated therapeutic principles, and often also investigated the effect of professional guidance. The studies based on CBT reported significant effects, but were limited in number. Interventions based on integrated therapeutic principles appear to be more effective compared to other therapeutic principles. There also appears to be a positive effect of professional guidance. However, the presented studies differed in reported effectiveness depending on setting, target group and follow-up period.

Cannabis

Single-session Interventions

Brief Interventions

Digital BIs are one-session interventions that are commonly delivered to non-treatment seeking adults or adults with less severe substance use patterns, which is usually reflected in broad inclusion criteria of the identified studies, such as cannabis us at least once in the past six, three or 1 month. Generally, the majority of available digital cannabis use reduction interventions are comprised of BIs as became apparent in a recent meta-analysis (Boumparis et al., 2019). From the subgroup analysis based on 3.023 participants from 13 RCTs, single-session BIs appeared to be associated with smaller effect sizes compared to multi-session digital interventions. However, many of those RCTs were targeting exclusively university students which differ tremendously from other target populations (Boumparis et al., 2019). However, studies have investigated the effectiveness of BIs for the reduction of cannabis use in different target groups and with use of different therapeutic principles, including PNF, MI or a combination of both. However, the number of studies investigating digital BIs for cannabis use reduction for adults is low and more studies, especially in non-student and clinical populations are needed to determine possible short and long-term effects.

In community settings, for example (Jonas et al., 2012), which was one of the first published digital intervention with the intend to reduce cannabis use, assessed the effectiveness of a single-session MI intervention delivered via a private online chat with a trained counselor. Via a drug-related information website, 302 problematic cannabis users (Severity of Dependence Scale [SDS; Steiner et al., 2008] $\geq$2/4 for females/males) were included. Compared to the educational control group, the intervention did not result in significant differences between-group differences regarding cannabis or alcohol use reduction at 1-month or 3-month follow-up.

In a different study, Becker et al. (2014) targeted tobacco smokers who also reported to use cannabis during the past 6 months and tobacco during the past 4 weeks. To this end, 325 participants were recruited from the community and randomized to receive a single-session BI with a PNF component, a single-session BI with an MI component, or an educational control condition. Although there was a significant increase in readiness to quit cannabis and tobacco in all groups at post-treatment assessment, but not at 8-week follow-up, there was no significant decrease in tobacco or cannabis use in any group at either follow-up assessment.

Multi-session Interventions

Integrated Therapeutic Principles

The majority of interventions targeting cannabis users include more than one behavioral change component. The most commonly encountered approach is CBT combined with MI.

Some interventions were aimed at less severe, non-clinical participants. For example, via a drug-related information website, Tossmann et al. (2011) recruited 1292 participants who expressed the wish to reduce their usage. The participants were randomized into a 50-day guided web-based intervention based on a solution-focused approach involving self-regulation and self-control components or into a WLC control condition. At 3-month follow-up the intervention condition showed a significant reduction in cannabis use compared to the control group ($d = 20$). In a different study, Rooke et al. (2013) recruited 230 past month cannabis users from the community and randomized them into a 6-session unguided web-based CBT + MI condition compared to an educational control condition. At 6-week post-treatment, the intervention group reported significantly less cannabis use days ($d = 0.38$),

quantity of use ($d = 0.34$), and less cannabis abuse symptoms ($d = 0.27$) during the past month compared to the control condition. During the 6-month follow-up the intervention effects were maintained, and the intervention condition reported significantly fewer and less severe cannabis dependence symptoms compared to the control condition ($d = 0$ .38). However, past month quantity of cannabis consumed did not differ anymore significantly between both groups ($p = 0.16$). Another study using the same therapeutic principles investigated the effect of an 8-session web-based intervention containing CBT and MI (Schaub et al., 2015). One intervention group was also offered the use of a chat function with a trained MI counselor. To this end, 308 past month cannabis users were included from the community. At 3-month follow-up, the mean number of cannabis use days per week was significantly lower in the intervention group receiving guidance compared to the intervention group who did not ($d = 0.34$). In addition, the guided intervention was significantly more effective compared to the WLC condition ($d = 0.20$), but no significant difference was observed when comparing the unguided intervention with the WLC condition.

Finally, Jonas et al. (2019) assessed whether treatment length and a chat-based MI component would affect treatment effects in reducing cannabis use. Therefore, they recruited 534 interested cannabis users via a drug-related information website. In a two-factorial design, participants were randomized to receive a 28-day or a 50-day guided web-based intervention based on a solution-focused approach involving self-regulation and self-control components (factor 1), with or without a chat-based MI component (factor 2). All groups significantly reduced their cannabis use at 3-month, 6-month and 12-month follow-up ($d \geq 1.13$). However, there was no difference in outcome between treatment duration. The chat-based MI component was also not associated with cannabis-related outcomes but with higher treatment satisfaction and stronger working alliance.

Some studies for the reduction of cannabis use have targeted clinical populations. For example, Budney et al. (2015) recruited 75 treatment-seeking adults with cannabis use disorder (based on DSM-IV) to investigate the effectiveness of a 9-session intervention containing CBT, MI and a contingency management condition in which patients received gift cards based on results of twice weekly urinalysis, either delivered FTF or on a computer, compared to a control condition of a 2-session MI intervention lasting approximately 60–75 min per session. Both intervention groups showed longer durations of continuous cannabis abstinence during the intervention compared to the MI condition, but did not differ from each other. Additionally, both groups maintained abstinence rates and reduction in days of use over time similarly. However, the computer-based condition was more cost-effective compared to the FTF condition, indicating that similar type of cannabis use reduction effects can be achieved when treatment is delivered in a computer-based format.

Summary on Technological Interventions Targeting Excessive Cannabis Use

The presented studies on the effectiveness of technological interventions for the treatment of excessive cannabis use have investigated single-session as well as multi-session interventions based on single or integrated therapeutic principles, targeting community or clinical settings. The interventions were mostly delivered through the internet, with follow-up periods ranging from 1 month to 12 months. The presented studies generally investigated multi-session interventions based on integrated therapeutic principles targeting community settings, which appeared to be effective at short- and longer-term follow-up.

Opioids

Single-session Interventions

Community Reinforcement Approach

The Community Reinforcement Approach (CRA) has shown its effectiveness in opioid use reduction. Specifically, in a previous meta-analysis that identified four RCTs targeting 584 opioid users with digital CRA-based interventions, a statistically significant difference compared to active control conditions ($g = 0.36$) was found (Boumparis et al., 2017). However, individual studies might show different finding based on their setting and target group.

For example in a community setting, Bickel et al. (2008) investigated the effectiveness of a 23-week CRA intervention in combination with voucher-based contingency management, either FTF or computer-based with guidance, compared with a 23-week TAU involving FTF counseling. To this end, 135 individuals who met DSM-IV criteria of opioid dependence were included from a university-based research clinic. At the post-treatment assessment, the computer-based intervention produced comparable weeks of continuous opioid and cocaine abstinence, but statistically significantly more weeks of abstinence compared to TAU. This indicates that guided computer-based CRA plus voucher based contingency management is a viable alternative to FTF treatment for opioid dependent adults. Similarly, Chopra et al. (2009) who made use of the same intervention as Bickel et al. (2008), with the difference that their intervention lasted 12 weeks instead of 23 weeks, recruited via the community 120 individuals who met DSM-IV criteria for opioid dependence. The participants were randomized into a 12-week guided computer-based CRA intervention, with voucher-based or medication-based contingency management, or into 12-week TAU involving FTF counseling. At the 3-month follow-up, no differences of opioid and cocaine-free urine samples were observed between the conditions. This contrasts the positive findings of Bickel et al. (2008) and might imply that longer and more intensive treatment might yield better outcomes in opioid dependent adults. However, in a similar study in a community setting, Christensen et al. (2014) did report significant effects of a 12-week computer-based CRA intervention with voucher based contingency management and buprenorphine medication compared to a 12-week intervention containing voucher-based contingency management and buprenorphine medication at 3-month follow-up in individuals meeting DSM-IV criteria for opioid dependence.

Finally, in a clinical setting, the most recent study investigating a computerized CRA intervention was conducted by Marsch et al. (2014) who recruited 160 patients who met DSM-IV criteria for opioid dependence. Participants were randomized into a 12-week

guided computer-based CRA intervention with reduced TAU, or TAU involving counseling. Participants in the intervention condition showed significantly greater rates of abstinence across all study weeks compared to the control group.

Summary on Technological Interventions Targeting Opioid Use

Although there is a limited number of studies regarding technological intervention for the treatment of excessive opioid use, the presented studies generally applied a single-session computerized community reinforcement approach in a community. Overall, the studies reported significant effects of the interventions on the reduction of opioid use. Due to the limited number of studies, more research is needed to investigate the effectiveness of technological interventions to treat excessive opioid use in different settings and through different modes of delivery.

Amphetamine-type Stimulants

Multi-session Interventions

Ecological Momentary Assessment

EMA is an innovative tool to collect valid data about behavior. EMA has proven to be useful in the addiction field because substance use tends to be episodic and is associated with the individuals' mood and their environment (Schulte et al., 2018; Shiffman et al., 2008). For example in a clinical setting, Reback et al. (2018) conducted a pilot study in which they recruited 34 treatment-seeking methamphetamine users who reported use in the previous 12 months. Participants were randomized into an 8-week smartphone-based EMA intervention in which they were able to self-monitor their methamphetamine consumption and risky sexual behaviors, with or without guidance. Guidance included weekly 30 min counseling sessions in which patients reviewed and discussed the self-monitoring data of the EMA application together. At post-treatment, both conditions showed a decrease in methamphetamine use according to the urine sample ($OR = 0.85$). However, no significant difference between the guided and the unguided intervention regarding methamphetamine use or risky sexual behaviors was found.

Cognitive Behavioral Therapy

CBT is one of the most commonly used psychotherapeutic interventions for the treatment of SUDs (Substance Abuse and Mental Health Services Administration, 2014). CBT is a multisession intervention targeting cognitive, affective, behavioral and environmental risks in substance users that has shown its effectiveness in alcohol use reduction and other primary substances (Magill et al., 2019). However, less is known about the effectiveness of CBT in amphetamine-type stimulant reduction. A meta-analysis by Harada et al. (2018) identified only two RCTs of which one suffered high attrition bias and the other had a small sample size, indicating that there is not enough evidence to establish the efficacy of CBT for amphetamine-type stimulant reduction. However, both studies will be discussed based on their setting and target group.

Tait et al. (2014) recruited via the community 160 amphetamine-type stimulant users who reported to have used an amphetamine-type stimulant in the past 3 months. They randomized the patients into (a) a 3-session unguided web-based CBT intervention or (b) a WLC condition. At 3-month follow-up, the authors reported high attrition and did not find a significant difference in amphetamine-type stimulant use between the two groups.

Summary on Technological Interventions Targeting Amphetamine-types Stimulants Use

The literature on the effectiveness of technological interventions for the treatment of excessive use of amphetamine-type stimulants is scarce. The two presented studies, which applied a different therapeutic principle in a different setting with a different delivery mode, both reported non-significant effects of the intervention under investigation. However, more research is needed in order to draw firmer conclusions.

Cocaine

Multi-session Interventions

Cognitive Behavioral Therapy

Two RCTs that included a digital CBT intervention targeting cocaine use were identified by a previous meta-analysis (Boumparis et al., 2017). Based on the subgroup analysis, small and non-significant effect of those interventions were found. However, given the small number of available studies and the high attrition rate no concrete conclusion as to the effectiveness of such interventions can be given. However, the two individual studies will be discussed based on their setting and target group.

To our knowledge, the first digital intervention targeting cocaine users was developed by Schaub et al. (2012), and included 196 individuals who reported to have used at least three times cocaine in the past 30 days from the community. The participants were randomized into either a 6-week unguided web-based CBT intervention or an educational control condition. Unfortunately, the dropout rate of the study was immense (>80%), which restricted the statistical power of the analyses. At 4-week, 6-week, and 6-month follow-up, no statistically significant differences were found between the intervention condition and the control condition.

In comparison, Carroll et al. (2014) investigated the effectiveness of an 8-week guided computer-based CBT intervention as add-on to TAU involving methadone maintenance compared to TAU-only. To this end, 101 treatment-seeking cocaine dependent individuals (based on DSM-IV criteria) were recruited from a clinical setting. At post-treatment, patients in the intervention condition were significantly more likely to show three or more consecutive weeks of cocaine abstinence compared to the TAU condition

($OR = 0.36$). Furthermore, at 6-month follow-up the results indicated that the effects were maintained and that the intervention condition was still performing significantly better in regards to cocaine use reduction. These results indicate that computer-based CBT when delivered as an add-on to methadone maintenance treatment could be a valuable addition to assist cocaine dependent individuals in reaching and maintaining abstinence to cocaine. However, more high-quality RCTs need to be conducted to reach a definite conclusion.

Integrated Therapeutic Principles

There are also some studies that have investigated the effectiveness of interventions incorporating multiple therapeutic treatment principles to target cocaine use in different target groups and different settings.

For example in a community setting, Schaub et al. (2019) recruited 416 cocaine users who reported to have used cocaine at least twice over the last 30 days. The participants were randomized into a 6-week web-based CBT and MI intervention with or without guidance by chat counseling, or the WLC condition. The frequency of cocaine use and severity of cocaine dependence decreased in both guided and unguided intervention groups but not in the WLC group. However, no significant difference was found between the intervention conditions or in the magnitude of change in the quantity of cocaine use per week between any of the three conditions.

A different study investigated the effectiveness of an 8-week guided computer-based CBT intervention plus CRA including cash-based contingency management compared to TAU plus CRA including cash-based contingency management (Brooks et al., 2010). To this end, 26 individuals who met the DSM-IV criteria for cocaine dependence were included and to have used cocaine at least once in the past 6 weeks. Arguably due to the low statistical power, no between-group differences were reported regarding cocaine use. However, the intervention was deemed feasible and acceptable given that patients were adhering to the computer-based CBT modules, therefore, the authors suggested that computer-based CBT in combination with cash-based incentives is an effective way to engage cocaine dependent patients.

Summary on Technological Interventions Targeting Excessive Cocaine Use

The literature on the effectiveness of technological interventions for the treatment of excessive cocaine use is scarce. The presented studies applied CBT or integrated therapeutic principles, in a community or a clinical setting, but generally reported non-significant effects of the intervention. However, more research is needed in order to draw a conclusion.

Polysubstance Interventions

Single-session Interventions

In the substance use literature, we have encountered a variety of interventions that were not specifically developed to treat substance users of one particular type of primary substance but were universal or targeting specific combinations of used substances.

For example, Gryczynski et al. (2016) recruited via a clinical setting 80 individuals scoring on the ASSIST between 5 and 26 and randomized them into (a) a 9 min unguided computer-based single-session BI, or (b) a WLC condition. However, no significant difference was found between the two conditions for ASSIST scores or for hair samples during the 3-month and 6-month follow-ups.

Blow et al. (2017) recruited 780 substance users presenting in an emergency department and randomized them to (a) 30 min unguided tablet computer-based BI, (b) a 30 min FTF BI with computer-supported guidance, or (c) TAU consisting of educational information on general health and HIV prevention. Patients were re-randomized during the 3-month assessment to either an adapted MI booster or enhanced TAU booster. Finally, the authors reported that from baseline to 12-month follow-up the percentage changes in mean days of any drugs used decreased significantly for patients in the FTF BI with computer-guidance (−26.7%) and the TAU condition (−20.9%) but not for the computer-based BI condition. However, there were no additional effects of the booster on substance use.

Schwartz et al. (2014) recruited via a clinical setting 359 individuals with an ASSIST score between 4 and 26 and randomized them into (a) a 7 min unguided computer-based single-session BI, or (b) a 14 min FTF BI. At 3-month follow-up, the authors reported that the computer-based and FTF-delivered interventions did not differ on global ASSIST drug scores or drug-positive hair tests. However, there was a significant difference of computer-BI over FTF BI in substance-specific ASSIST scores for marijuana ($d = 0.26$) and cocaine ($d = 0.50$), indicating that computer-based BI is a valuable intervention that has the potential to even outperform FTF-delivered BIs.

The study by Ondersma et al. (2007) recruited via a clinical setting 107 post-partum women that reported any type of substance use 30 days prior their pregnancy. The authors randomized the individuals either to (a) a 20 min unguided single-session computer-based BI + MI, or (b) an assessment-only condition. At 4-month follow-up, the intervention group significantly decreased in frequency of any drug use other than cannabis compared to the assessment-only condition ($d = 0.50$). Given the initial success of their study, the authors decided to conduct a further study, in which they recruited via a clinical setting 143 post-partum women that reported any type of substance use 30 days prior their pregnancy (Ondersma et al., 2014). The individuals were randomized either to (a) a 20 min unguided single-session computer-based BI + MI, or (b) an assessment-only condition. At 3-month follow-up, a significant difference was found in individuals being abstinent over the past week for any drug use compared to the assessment-only condition ($OR = 3.3$); furthermore, the effects were according to the hair analyses maintained during the 6-

month follow-up ($OR = 4.8$), indicating that a brief intervention might have valuable short-term and long-term effects in postpartum women that report using substances.

Braciszewski et al. (2018), who recognized the need for an unguided smartphone-based BI + MI for substance use reduction in young adults exiting foster care, recruited 33 young adults and compared the intervention with an attention-control condition. Both conditions lasted 6 months. The authors reported that at every timepoint up to the 12-month follow-up, the intervention condition showed greater percentages of abstinent days from the primary substance of choice (effect sizes ranging from $d = 0.32$ to 0.62). Given the promising findings, larger studies should be conducted to reach definite results about smartphone-based interventions in this and other target populations.

Finally, Drislane et al. (2020) recruited 780 patients scoring ≥ 4 on the ASSIST for any illicit or misused prescription drug via a clinical setting. Participants were randomized into (a) 30 min tablet-based BI with an MI component, (b) a 30 min FTF BI with an MI component, or (c) TAU involving the review of health resources brochures in the emergency department. The FTF BI condition was associated with significant reductions in cannabis use and anxiety compared to the TAU condition but showed no effect for alcohol use. The intervention condition had no significant effect on those measures. The results indicated that the FTF BI condition was associated with significant reductions in cannabis use and anxiety compared to the TAU condition but showed no effect for alcohol use. The tablet-based BI condition had no significant effect on cannabis use, alcohol use, and anxiety measures.

Multi-session Interventions

Cognitive Behavioral Therapy

Kiluk et al. (2018) recruited from a clinical setting 137 treatment-seeking patients presenting with any DSM-IV substance dependence disorder and randomized them to either (a) a 12-week guided computer-based CBT intervention plus weekly brief 10 min FTF monitoring, (b) 12-week FTF CBT, or 12-week TAU entailing weekly counseling. At post-test, there was no difference between the computer-based and FTF-delivered CBT condition, however, both, the computerized intervention ($t = -2.26$) and FTF CBT ($t = -3.41$) performed significantly better in substance use reduction compared to TAU. Interestingly, for the guided computer-based CBT condition, these results were maintained at 6 months, but not for the FTF CBT condition ($t = -2.02$). These results indicate that computer-based CBT in combination with brief weekly monitoring may be a valuable alternative to intensive FTF-delivered CBT, which could potentially have even longer lasting effects. However, given the small sample sizes were relatively small, more high quality and larger RCTs are needed to reach definite conclusions.

Paris et al. (2018) recruited 92 treatment-seeking individuals via a clinical setting that presented any DSM-IV substance abuse or dependence disorder according to the DMS-IV and randomized them into (a) an 8-week unguided computer-based CBT intervention plus TAU, consisting of weekly supportive counseling, or (b) TAU-only. At post-test, the internet-based CBT + TAU condition showed significantly greater substance use reduction compared to the TAU-only condition ($d = 0.13$). Similarly, Carroll et al. (2008) recruited 92 treatment-seeking individuals via a clinical setting that presented any DSM-IV substance abuse or dependence disorder according to the DMS-IV and randomized them into (a) an 8-week unguided computer-based CBT intervention plus TAU consisting of weekly counseling. At 8-week follow-up, patients assigned to the intervention condition submitted significantly more negative urine specimens for any type of drugs ($d = 0.59$) and tended to have longer continuous periods of abstinence ($d = 0.45$). Furthermore, treatment engagement was stronger in the computer-based CBT condition compared to the TAU-only condition.

Finally, an interesting study by Acosta et al. (2017) recruited via a clinical setting 162 problem drinking (AUDIT score $> 8/> 7$ for men/women) or substance misusing (DAST-10 score ≥ 2) veterans with subthreshold PTSD and randomized them to either to (a) 12-week unguided web-based CBT plus TAU consisting of veteran affairs primary care services including medical, behavioral health, pharmacy, weight management, and social work services, or (b) TAU-only. Both interventions were targeting symptoms of substance use and post-traumatic stress disorder concurrently. The authors reported that the web-based CBT plus TAU condition produced a greater reduction in heavy drinking outcomes compared to the TAU-only condition but not for other substances, PTSD symptoms, or quality of life.

Community Reinforcement Approach

We identified only one multi-session CRA study, specifically, Campbell et al. (2014) recruited in a clinical environment 507 substance users that indicated that they had used illicit substances in the past 30 days before entering the study, or 60 days for those exiting a controlled environment. The authors randomized the patients into (a) 12-week guided computer-based CRA + price-based contingency management + TAU involving counseling, or (b) TAU- only. At post-test, the authors reported that patients in the intervention condition had a statistically significant lower dropout rate ($HR = 0.72$) and a greater abstinence rate ($OR = 1.62$) compared to the TAU condition.

Integrated Therapeutic Principles

The study by Aharonovich et al. (2017) recruited in a pilot-study via a clinical setting 42 HIV-positive, non-injecting drug users that reported to have used in the last 30 days non-injection drugs ($\geq$4 days of crack/cocaine, methamphetamine, or heroin use) and binge drinking ($\geq$1 day of 4+standard drinks). They randomized the patients into (a) MI + a smartphone-based intervention consisting of self-monitoring, positive reinforcement, personalized feedback, and MI, or (b) MI-only. At 2-month follow-up, the intervention group experienced a greater reduction in the total number of drinking days and total number of drug use days compared to the MI-only group ($IRR = 0.59$).

Summary on Technological Interventions Targeting Excessive Polysubstance Use

The presented studies on the effectiveness of technological interventions for the treatment of excessive poly-substance use have investigated single-session as well as multi-session interventions based on a single therapeutic principle or integrated therapeutic principles, mainly targeting a clinical setting. Follow-up periods generally ranged from 2 months to 1 year and the interventions were predominantly computerized. The results were ambiguous with significant as well as non-significant effects of the intervention on polysubstance use, which appeared to be regardless of the number of sessions, therapeutic principle or follow-up period.

Future Research Directions

Many opportunities remain for future research, which might be different depending on the substance that is targeted. For example, in the field of alcohol and cannabis interventions, most studies have investigated unguided standalone interventions compared to non-active controls. Although the number of studies using add-on or blended interventions compared to active controls have increased, future research could benefit from more extensively investigating the effectiveness these types of interventions. With respect to psychostimulants, the types of interventions that have been investigated appear to be more distributed. However, due to small body of research in the field of illicit substances, including cocaine and opioids, more research into the effectiveness of technological interventions targeting illicit substances is needed.

In addition, there are some future directions from which could be benefited regardless of substance type. First, future studies on the effectiveness of technological interventions for the treatment of SUDs could benefit from a standardized approach. Many discrepancies between studies could be explained by methodological differences between studies. For example, a variety of outcome measures is used to assess post-treatment substance use, including subjective (e.g., self-report, questionnaires) as well as objective measures (e.g., breathalyzers, urine samples). This variety in outcome measures could contribute to discrepant study outcomes, because an intervention could have an effect on one outcome but not another. One example of the development of standardized outcome measures is the "Outcome Reporting in Brief Intervention Trials: Alcohol" (ORBITAL) project, which aims to develop a core outcome set and reporting guidelines for efficacy and effectiveness trials of alcohol brief interventions (Shorter et al., 2017). In a recent international e-Delphi study as part of the ORBITAL project, several outcomes for alcohol brief interventions were prioritized, including typical frequency, alcohol-related problems, and at-risk drinking (Shorter et al., 2019). In addition, future research could benefit from standardizing the time points of outcome assessment. Although this is to some extent inherent to the duration of the intervention under investigation, the moment when the post-intervention or even the follow-up assessment takes place varies considerably between studies. Future research could benefit from standardizing the assessment time points to increase inter-study comparability and to get a clearer view on short- and long-term effects of technological interventions for the treatment of substance use.

Second, several RCTs have investigated the effectiveness of a multi-component intervention. However, when an intervention is reported to be successful, it remains unclear which component or combination of components has contributed to the significant effect of the intervention. Vice versa, when an intervention is reported to be not successful, it remains unclear if there were any effective components in the intervention which effects was canceled out by other components. Future research could benefit from identifying effective components, for instance by means of Multiphase Optimization Strategy (MOST; Collins et al., 2007). However, some studies have aimed to identify effective components of multi-component interventions. Based on a narrative review by Gaume et al. (2014), there appear to be several effective components, including personalized feedback and motivational interviewing techniques. Several components that could potentially mediate the effectiveness of an intervention include client change talk and readiness to change. Furthermore, Grekin et al. (2019) have performed a factorial trial to disentangle the effectiveness of four components (MI strategies present (y/n), empathic reflections present (y/n), animated narrator present (y/n), and spoken voice present (y/n)), resulting in 16 conditions. Of these four components, only MI strategies being present appeared to have significant effects on drinking behavior at 6-month follow-up. Similarly, Neighbors et al. (2019) tested eight versions of PNF that were consistent or inconsistent with the Deviance Regulation Theory, that states that individuals behave to be in line with other's behavior. In eight intervention groups, different variations of describing specific drinking behaviors as common on uncommon, whether the drinking behaviors were healthy or unhealthy, and whether the drinking behaviors were negatively or positively framed were evaluated. It was concluded that the interventions that made use of unhealthy drinking behavior messages, especially when described as uncommon, were most effective to significantly reduce the number of drinks in the past month and alcohol-related problems. In addition to identifying active components of the intervention itself, future research could also benefit from investigating the effect of using different modes of delivery. For example, investigating effectiveness of interventions that are delivered by means of telephone, SMS or through the internet, and investigating effectiveness of using different formats, such as providing the intervention as guided, unguided or blended treatment, and as a standalone intervention or as add-on to for example treatment as usual.

Third, as with any intervention, the effectiveness of technological interventions for the treatment of substance use could be affected by several moderators. Factors such as age, gender, ethnicity, digital literacy and severity of the disorder could all potentially influence the effectiveness of an intervention. For instance, it remains unclear how BIs can be optimized for target groups including pregnant women, adolescents, older adults, ethnic minority groups (Kaner et al., 2018; O'Donnell et al., 2014), or groups with lower socioeconomic status (SES) or low literacy. Although no differences in effectiveness between European and non-European countries have been reported (Elzerbi et al., 2015), it is important to investigate the effectiveness in low-income countries.

Fourth, many studies have investigated the effectiveness of an intervention in terms of statistical significance. However, statistical non-significance does not imply clinical non-significance. Specifically, a small change that does not reach statistical significance could very well have clinical significance for a patient.

Finally, future research could also benefit by investigating different approaches to improve effectiveness. For example, transdiagnostic approaches could be a way forward as there is high comorbidity with other mental disorders. In addition, although it was beyond the scope of the current chapter, experimental approaches such as cognitive bias modification training could be explored to add to the effectiveness of existing (technological) interventions for the treatment of SUDs.

Clinical Applications and Recommendations

Based on the previous sections, a large amount of RCTs support the notion that digital interventions for SUDs are feasible and can be effective in reducing substance use. The assessed RCTs also provide proof that many psychotherapeutic treatments can be delivered to a variety of substance users via digital formats. Given that digital interventions have frequently shown to be at least as effective compared to evidence-based face-to-face treatments in providing equivalent benefits and outcomes in a variety of substance users, it becomes increasingly clear that digital interventions will play a key role for individuals who are willing to receive treatment that might otherwise not have been accessible. In addition, digital intervention might be especially suited for certain individuals that feel uncomfortable seeking face-to-face help for their concerns or believe that their problem does not warrants a doctor's visit but who would follow a digital treatment plan in their own pace. Digital interventions have the possibility to decrease many barriers inherent in the mental health care deliverance model, such as limited skilled therapists, long waiting time for the simple dissemination of information, length of treatment, and time conflicts. However, it is not advocated to replace face-to-face treatments with digital intervention but rather, that they are well-suited to provide an alternative or blended component to traditional psychotherapeutic interventions for substance users. Furthermore, the importance that therapists will require training in digital interventions and their delivery to use these forms of treatment within their professional work should be emphasized.

Technological delivered interventions for the treatment of substance use can have other benefits in addition to increasing accessibility for potential patients. For example, when face-to-face treatments are not feasible due to different reasons, for example during the COVID-19 pandemic, switching to technological solutions could prevent a cessation of treatment for substance use and mental health in general (Wind et al., 2020). Another benefit could be cost-effectiveness. Digital interventions are often being advertised for their potential cost-effectiveness compared to traditional treatments, however only limited research in the substance use literature is available on this subject (Blankers, 2016).

Conclusion

This chapter focused on technological interventions for the treatment of substance use disorders. To this end, the effectiveness of various evidence-based psychosocial therapies (e.g., CBT and MI) that were digitally delivered to target excessive substance use (e.g., alcohol, cannabis and illicit substances) were discussed. Literature on single-session interventions as well as multi-session interventions was discussed. Although the overall effects of technological interventions based on several therapeutic principles appeared to be effective in targeting the use of the different substances based on several meta-analysis, individual studies provided a more heterogeneous picture.

Regarding the literature on technological interventions on excessive alcohol use, single-session as well as multi-session interventions based on a single-focus therapeutic principle or integrated therapeutic principles, targeting community, clinical and workplace settings were investigated, with follow-up periods ranging from 1 month to 1 year. Single-session interventions applied personalized normative feedback or integrated therapeutic principles. The results were ambiguous, with significant as well as non-significant effects on drinking behavior. The ambiguity was regardless of setting, follow-up period or mode of delivery. Moreover, results tended to be significant for specific sub-groups of heavier drinkers, but had tapered off at long-term follow up. The presented multi-session interventions were solely based on CBT or on integrated therapeutic principles and often also focused on the effects of professional guidance. The studies based on CBT reported significant effects, but were limited in number. Interventions based on integrated therapeutic principles appeared to be more effective compared to other therapeutic principles. There also appears to be a positive effect of professional guidance. However, the presented studies differed in reported effectiveness depending on setting, target group and follow-up period.

The presented studies on the effectiveness of technological interventions for the treatment of excessive cannabis use have investigated single-session as well as multi-session interventions based on single or integrated therapeutic principles, targeting community or clinical settings. The interventions were mostly multi-session interventions based on integrated therapeutic principles, targeting community settings through the internet, with follow-up periods ranging from 1 month to 12 months. The results were generally positive regardless of the number of sessions or follow-up period.

The literature on technological interventions for the treatment of excessive use of illicit substances, including cocaine, amphetamine-type stimulants and opioids, is scarce and the effects ambiguous, with significant as well as non-significant effects. The presented studies on interventions for the treatment of excessive opioid use generally target community settings, whereas the presented studies on interventions for the treatment of excessive cocaine or amphetamine-type stimulant use target clinical

as well as community settings. However, the ambiguity appeared to be regardless of setting, number of sessions, mode of delivery or therapeutic principle.

The presented studies on the effectiveness of technological interventions for the treatment of excessive poly-substance use have investigated single-session as well as multi-session interventions based on a single therapeutic principle or integrated therapeutic principles, mainly targeting a clinical setting. Follow-up periods generally ranged from 2 months to 1 year and the interventions were predominantly computerized. The results were ambiguous, with significant as well as non-significant effects of the intervention on polysubstance use, which appeared to be regardless of the number of sessions, therapeutic principle or follow-up period.

Directions for future research were provided based on the heterogeneity within studies as well as directions based on general issues regardless of type of substance. First, more research into different intervention types is needed such as add-on or blended interventions compared to active controls, especially in the fields of alcohol and cannabis research. Additionally, more research into the effectiveness of technological interventions targeting illicit substances is needed. Second, future research could benefit from standardization of the approach, including standardization of outcome measures or assessment time points. Third, effective components of a multi-component intervention need to be identified to compile more effective interventions. Fourth, the effects of moderators such as age, gender, ethnicity, digital literacy and SUD severity need to be investigated in order to tailor interventions to specific target groups to further enhance their effectiveness. Last, researchers should not only consider statistical significance, but also clinical significance, and consider transdiagnostic approaches to target comorbid mental disorders.

The chapter closed by discussing clinical implications, including highlighting that digital interventions will play a key role in overcoming certain treatment barriers experienced by potential patients and overcoming difficulties when face-to-face treatment is not possible (e.g., during the COVID19 pandemic). However, therapists require training in digital interventions and their delivery to use these forms of treatment within their professional work.

In sum, the presented studies investigating the effectiveness of technological interventions for the treatment of excessive alcohol, cannabis, opioid, amphetamine-type stimulant, cocaine or polysubstance use applied a single-session or multi-session approach based on single-focus or integrated therapeutic principles. They targeted community, clinical or workplace settings, and were delivered online, through smartphones or on a computer. Overall, the results are ambiguous, with significant and non-significant effects on substance use. However, more research is needed to investigate how interventions can be optimized and potentially tailored to specific groups, by considering aspects such as intervention type, standardization, identifying active components and considering moderating factors that might influence the effectiveness of the intervention.

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