The future of dynamic networks in research and clinical practice

A problem attracts other problems[1]. An individual having one symptom (e.g., feelings of sadness) often will have more symptoms over time (e.g., sleep disturbances). The observation that symptoms generate other symptoms has led to the highly influential psychopathological network theory, in which the focus is on how mental disorders can be seen as networks of interacting symptoms[2]. In such psychopathological networks, symptoms are the nodes, and the connections between them are termed edges.

The network theory posits that individuals can have different symptom networks, which can also change within a single person over time. Not only are the symptoms in the network likely to be different between individuals; the connections between the symptoms are also likely to differ. Whereas for person A having sleep disturbances may trigger suicidal thoughts, this may not be the case for person B. Subsequently, a central notion stemming from network theory is that interventions should not only target symptoms, but also the connections between them, breaking the vicious cycle.

In clinical research and practice, networks for patients are often inferred from time series data based on symptom and/or emotion questionnaires that are administered several times a day over, for instance, a time period of several weeks. Networks based on such data have been called *person-specific dynamic networks*. Even though the models used for inferring these dynamic networks are not new, what is new is the visualization of these models, which makes network modelling appealing and tangible for both research and clinical practice[3].

What is often overlooked in the field is the need to bridge the gap from an insightful theory to an actual model. To get from a network theory to a model there are, broadly speaking, two steps that need to be made. The first step concerns the kind of data to be collected from the patient, and the second regards the modeling of these data in such a way that it does justice to the theory.

Thus, the first step to a dynamic network model is collecting and selecting the necessary data. In the network theory, the focus has been on symptoms and emotions, and thus most person-specific dynamic networks almost exclusively include symptoms and/or emotions items. However, further behavioral, context and cognitive items could be included in the networks[4]. Emotions and symptoms indicate how a patient is doing, whereas behavioral, context and cognitive items can lead to insights on why the patient is feeling a certain way. This can help in targeting therapeutic interventions, for example, by indicating behaviors, social contacts or thoughts that lead to feelings of sadness. Additionally, these items should be formulated and personalized in terms of content in collaboration with the patient, which can result in a higher chance of capturing crucial aspects of his/her daily life, and better reflect his/her interests and experiences in general[5].

Other sources than questionnaire data should also be considered, such as social media, passive sensing, and many other available kinds of time series data. Collection of passive sensing data (e.g., location tracking of mobile phones) can lead to reduction of the burden on the patient, as the data are gathered automatically. In addition, it can provide new therapeutically relevant insights complementing questionnaire data. For example, if a patient with social anxiety indicates in a questionnaire that she followed a lecture, it is not clear from this whether she had a breakthrough and actually went to campus, or watched the lecture online at home, but location tracking data can provide this complementary information.

After the source of data has been chosen, a model needs to be identified to infer the network. With regard to this second step, models based on vector autoregression are the most commonly used to infer these person-specific networks. A vector autoregressive model allows to study, for instance, reciprocal predictive effects: does stress predict one's sadness at the next time point, the other way around, or are both stress and sadness predictive of each other?

Although this model does justice to the dynamic structure of data, it is too limited to capture all aspects of the network theory. In fact, it cannot deal with change in the network, whereas this is often one of the main elements of interest (e.g., did the mood of the patient improve and why?). Furthermore, different variables measured at different time scales (e.g., sleep quality vs. mood) cannot be modeled simultaneously, meaning that often factors such as sleep quality (measured once a day) are not taken into account into the network, even though they are known to affect one's mood (mood is often measured several times a day). Additionally, these models are very data hungry, meaning that many time points (more than 100 per individual) are often needed to model all relevant variables in the network[6].

Beyond the many different choices that one could make in the pursuit of a network model, one could also take a different direction altogether. Network theory itself is not tied to any model, nor to a number of variables. Thus, fitting a vector autoregressive model on all relevant variables to infer a dynamic network is neither necessary nor *per se* advisable, as including more variables but not increasing the number of time points will only decrease the accuracy of the estimated network[7].

Instead of the rather ambitious and broad goal of trying to unravel the dynamic processes between symptoms, a more viable approach could be to test specific and targeted questions, which often emerge naturally between patient and therapist (e.g., in functional analysis)[8]. Studying the relation between only two variables can already be of interest: for example, studying whether a specific physical activity leads to a positive change in one's sleep pattern. This is still in line with the network theory (how do variables influence each other), but, given the focus on change, should not be studied with the standard vector autoregressive model[9]. Rather, it could be studied with, for instance, regime-switching models. With these models, one could investigate whether there are different regimes in the data, and whether the regime of more

physical activity (vs. less physical activity) is associated with a positive change in one's sleep pattern[4]. In general, different questions might require different (network) models. Therefore, a broadening of our available arsenal of statistical techniques is also essential to optimize the move from network theory to an actual model.

To summarize, we see that until now dynamic networks have been implemented in a rather restrictive way, in which often only specific variables and one specific model are commonly used. Importantly, the network theory puts no constrains on the data and the model used to come to a person-specific network. This means that in the future we do not have to hold on to specific data or models. In the end, researchers and clinicians alike should explicate how they want to apply the network theory to the specific patient and situation, and then consider what kind of data and model is best suited for that purpose.

Laura F. Bringmann
Department of Psychometric and Statistics and Interdisciplinary Center Psychopathology and Emotion regulation (ICPE), University of Groningen, Groningen, The Netherlands

1. Fried EI, Cramer AO. Perspect Psychol Sci 2017;12:999-1020.
2. Borsboom D. World Psychiatry 2017;16:5-13.
3. Epskamp S, Cramer AO, Waldorp LJ et al. J Stat Softw 2012;48:1-18.
4. Bringmann LF, Albers C, Bockting C et al. Behav Res Ther 2022;149:104011.
5. von Klipstein L, Riese H, van der Veen et al. BMC Med 2020;18:1-8.
6. Bringmann LF. Curr Opin Psychol 2021;41:59-64.
7. Mansueto AC, Wiers RW, van Weert J et al. Psychol Methods 2023;28:1052-68.
8. Scholten S, Lischetzke T, Glombiewski JA. Psychother Res 2022;32:52-64.
9. Haslbeck JMB, Ryan O. Multivar Behav Res 2022;57:735-66.

The promise of social recovery therapy in non-affective psychoses

Non-affective psychoses (schizophrenia and schizophreniform disorders) are the health conditions of working age adults most frequently associated with poor social outcomes. Long-term follow-up studies suggest that less than 50% of people with these conditions achieve social recovery, less than 15% achieve sustained recovery in both symptomatic and social domains, and only 10-20% of people return to competitive employment, despite the majority reporting that they wish to work[1].

Social recovery therapy (SRT) is a psychosocial treatment to promote social recovery in people with non-affective psychosis who are socially withdrawn, have complex and comorbid problems, and are unresponsive to existing interventions. It is based on a model in which social disability evolves as a result of lifestyle patterns of low activity, adopted to achieve behavioral avoidance, and maintained by lack of hope, agency and motivation.

Social disability in psychosis typically occurs in the context of persistent positive and negative symptoms and cognitive impairment, often accompanied by depression, anxiety and other psychopathological manifestations. Alongside such issues are complex social circumstances and systemic issues, including problematic family dynamics, victimization, social threat and social deprivation. In the face of such problems, individuals adopt lifestyle patterns of extreme social withdrawal, leaving work or education and losing contact with social networks.

SRT is described in a manual[2] and delivered individually across 9 months. Sessions take place in participants' homes and community locations. Interim telephone and email contact usually occurs. SRT delivery is structured in three stages. Stage 1 includes assessment and development of a shared social recovery formulation. Stage 2 involves identifying and working towards medium- to long-term goals guided by a systemic formulation of barriers to recovery, with a focus on promoting a sense of agency, hope and motivation, and encouraging activity while managing psychotic symptoms. Stage 3 involves the active promotion of structured activity linked to meaningful goals, while still managing symptoms.

The focus of the intervention is on the individual's personal values and goals, identifying problems and barriers to these, then promoting hope for meaningful behavioral change and activity toward these goals. There is a strong emphasis on the use of behavioral strategies (including behavioral experiments, graded exposure and behavioral activation) to overcome avoidance and promote meaningful lifestyle change *in vivo* whilst managing symptoms as necessary to implement a concrete pathway to social recovery. Evidence and experiences from this behavioral work are used to further instill hope and promote positive beliefs about self as the individual works towards achieving meaningful change in his/her life.

As SRT aims to engage people with psychosis into structured activity, it often includes supporting them to access employment, education, training, voluntary and/or leisure opportunities. Much of SRT takes place in community settings. It is often useful for the therapist to drive the client to new locations and settings or accompany him/her on public transport.

To achieve gains in social recovery against a background of often years of withdrawal and social disadvantage means that therapists have to integrate techniques typically associated with assertive community treatment and supported employment. Working systemically with families and stakeholders surrounding the individual to promote opportunities in the social environment is also important. Behavioral activation and behavioral experiments are conducted in line with the client's identified goals and values and at a pace respecting the nature of the difficulties faced. The therapist works alongside the client to aid motivation and engagement in identified activities that can be incorporated into daily life, and work out collaborative strategies to manage ongoing symptoms *in vivo*.

To date, we have conducted two assessor-blind randomized controlled trials of SRT in people with psychosis with severe social disability.