Interaction-based phenotyping as observer-independent measures of social impairments across psychiatric disorders

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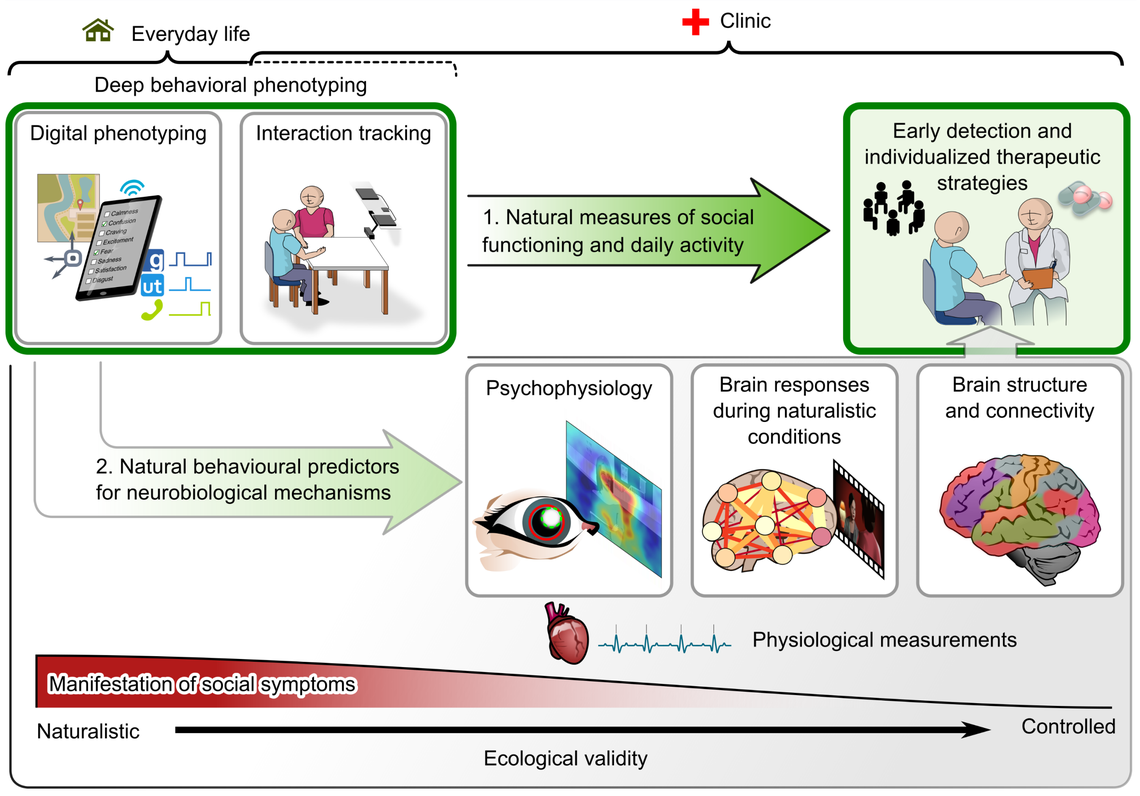
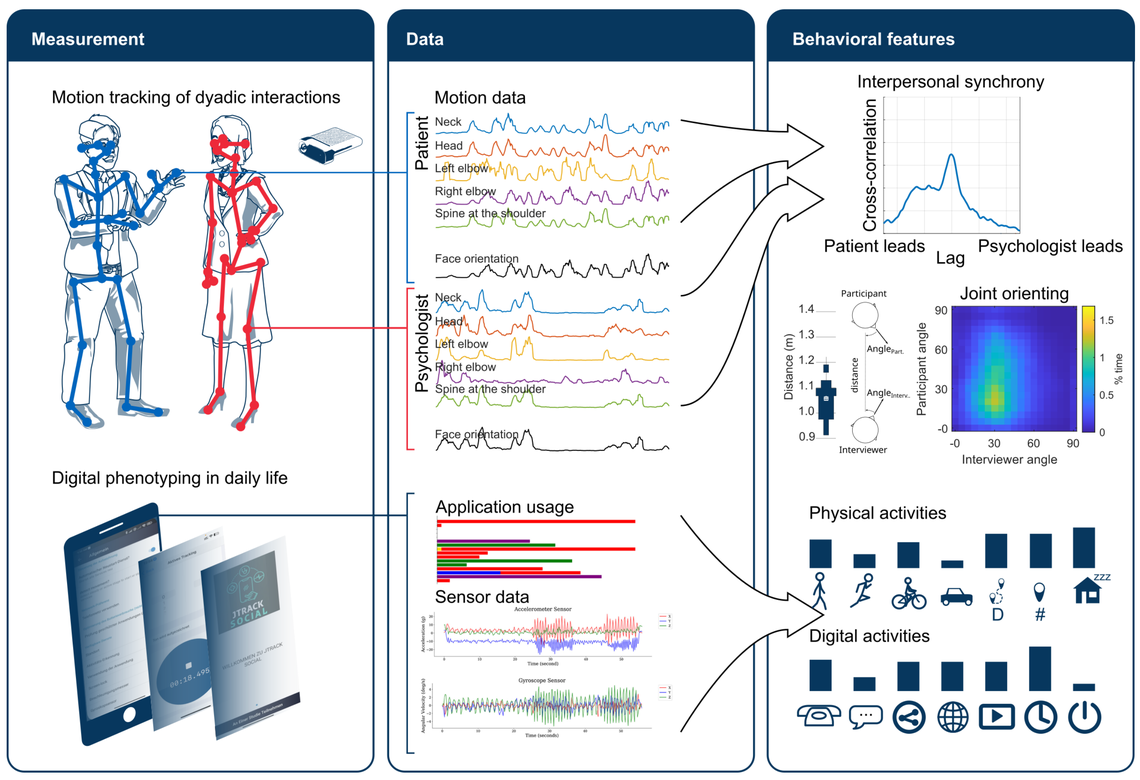
Introduction

Mental health conditions impose a rising burden on societies around the world. Yet, the society is ill-equipped to address the problem due to limited understanding of the range of effects and underlying causes of mentally ill health and a lack of appropriate individualized interventions (Patel et al., 2018).
Psychiatric conditions are, perhaps universally, characterized by disordered social interactions (Schilbach, 2016). Most behavioral measures aiming to evaluate these social deficits rely on subjective scales to assess the symptoms. Truly objective, quantitative measures remain scarce in both research and clinical practice limiting the ability to independently measure social disturbances.
Deep behavioral phenotyping of natural social behavior may provide a more objective window into individual social difficulties with applications in both clinical practice and in research into the neural constituents of the behavioral phenotypes. Here, we present initial findings and future outlook of quantitative behavioral measures as potential direct and objective markers for detection and subsequent quantitative monitoring of mental health conditions through social and physical activity patterns.

Methods

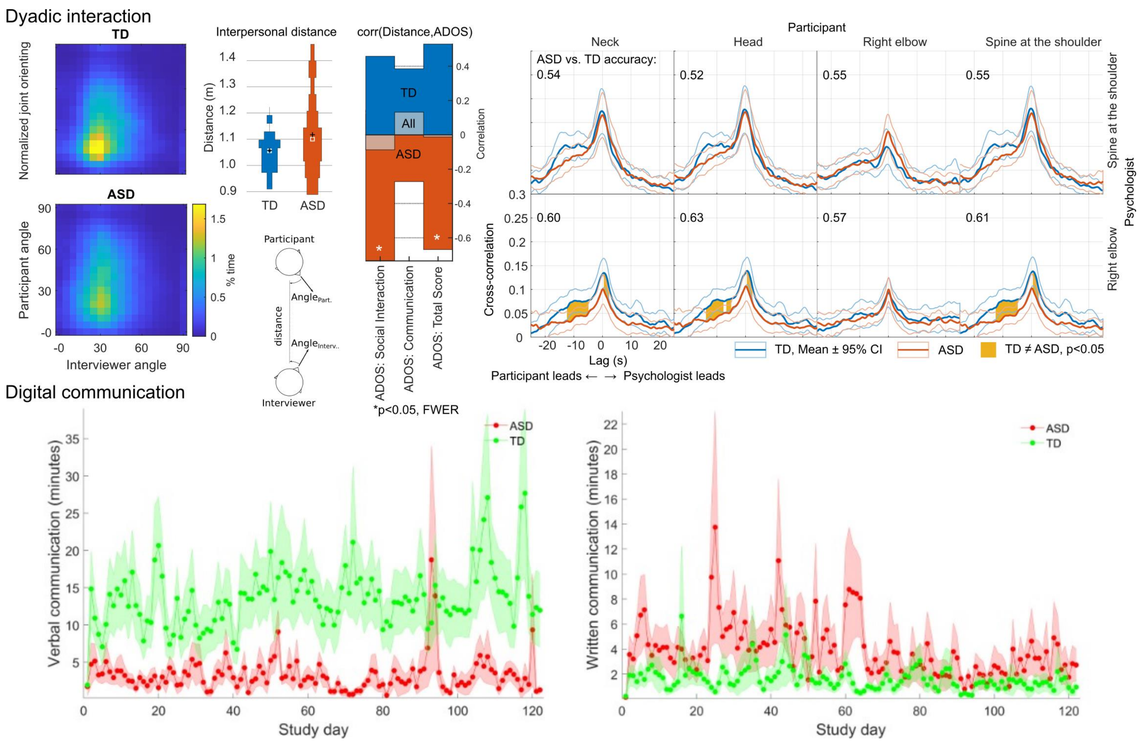


Our framework emphasizes deep behavioural phenotyping in natural conditions of everyday life and minimally constrained interactions (green box, top left). These approaches can (1) provide objective measures of daily functioning that can directly guide early detection and individual intervention strategies in the clinic, thus helping with the limitations of in-clinic evaluations. Additionally, (2), the individual measures of daily functioning may help to uncover neurobiological markers of the symptom dimensions without relying on heterogeneous disease labels. These findings may then feed back to clinical practice. (Lahnakoski et al. 2021)



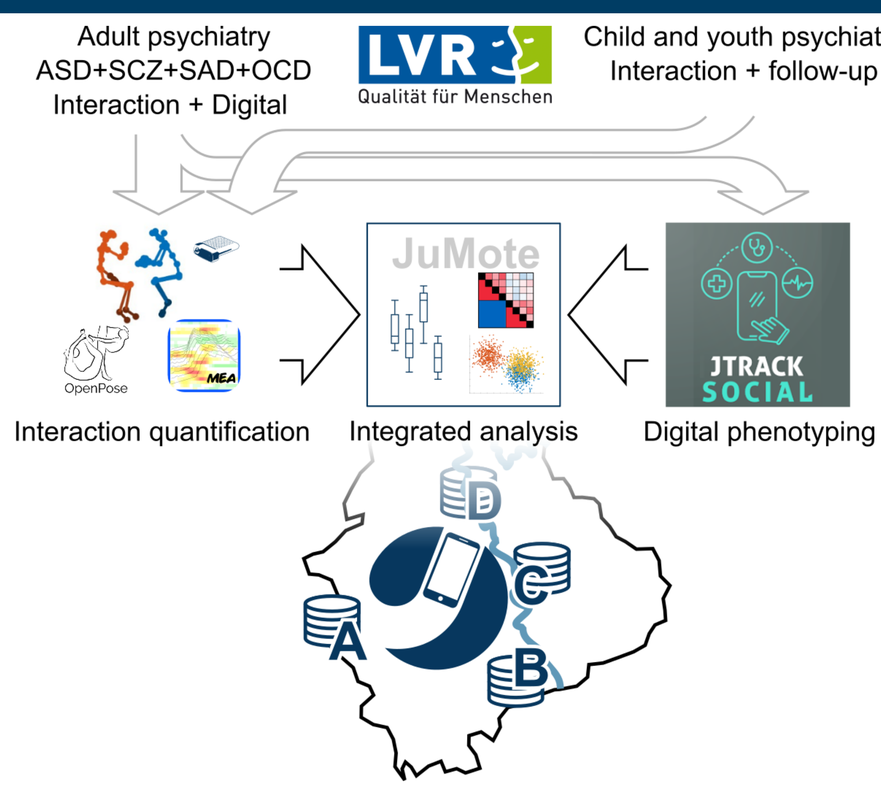
Measurement of behavior *(left)* during dyadic interaction employs the Microsoft Azure Kinect DK together with the "JuMote" toolbox, which is currently in pilot phase. Digital phenotyping employ JTrack Social app installed on participants smartphone to quantify behavior during everyday life.
The data *(middle)* produced by the tracking software includes motion data (location, orientation and confidence) for joints of the motion tracking skeleton model and sensor data (randomized GPS data, accelerometer data; Sahandi Far et al. 2021) and application usage statistics from the digital phenotyping application.
These data are further processed (right) to derive interpersonal and individual level features quantifying behavioral patterns such as interpersonal coordination, distance and joint facial orienting from the motion tracking data. The digital phenotyping includes statistics of physical activities (e.g. walking, running driving, distance covered) and digital activities (e.g. phone calls, text messages, social media and internet usage).

Behavioral correlates of autism spectrum disorder



Top: During dyadic interaction, joint facial orienting histograms (left) reveal that, during a diagnostic interview, direct reciprocal face-to-face orienting are reduced (joint low face angles), in the ASD group compared with controls. Concurrently (middle), interpersonal distance shows more variability in the ASD group and is negatively correlated particularly with the social interaction subscale of ADOS in the patient group. Participant-initiated cross-correlations (right) are reduced between the patient-interviewer vs. control-interviewer dyads.
Bottom: In digital communication ASD group spend consistently less time in verbal communication (left) and more time in written communication (right) compared to the TD group over study duration.

Future outlook



Intermediate scale transdiagnostic study (top-left) on autism spectrum disorder, schizophrenia, social anxiety disorder and obsessive compulsive disorder (N=60/group) and (top-right) and a developmental study (top-right) on behavioral patterns in parent-child dyads in child and youth psychiatry are planned. These will enable further development of the behavioral analysis tools to enable standardized, integrated analyses of behavioral tracking patterns gathered through motion capture (e.g. Kinect) and video-based (e.g. motion energy analysis, OpenPose) applications and digital phenotyping features. Promising behavioral markers are planned to be further validated in larger samples with collaborating psychiatric clinics (bottom) and integrated with the shared data infrastructure and neuroimaging studies.

Conclusions

- Quantitative deep behavioral phenotyping may assist in detecting individuals with consistent behavioral phenotypes with potentially similar underlying causes for their symptoms, guiding the analysis and modelling of the underlying causes
- Initial result in autism spectrum disorder indicate consistent differences in face-to-face and digital communication pattern compared with typically developed controls
- Further transdiagnostic and developmental studies are needed to assess the specificity of the behavioral markers

Acknowledgments
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References
Lahnakoski et al. (2021) Naturalizing psychopathology - towards a quantitative real-world psychiatry. Mol psychiatry. doi: 10.1038/s41380-021-01322-8
Patel et al. (2018). The Lancet Commission on global mental health and sustainable development Executive summary. The Lancet, 392, 1553–1598. https://doi.org/10.1016/S0140-6736(18)31612-X
Sahandi Far et al. (2021). JTrack: A Digital Biomarker Platform for Remote Monitoring of Daily-Life Behaviour in Health and Disease. Front. Public Heal. 0, 1844. Doi:10.3389/FPUBH.2021.763621
Schilbach (2016). Towards a second-person neuropsychiatry. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 371(1686), 20150081. https://doi.org/10.1098/rstb.2015.0081