KU LEUVEN

FACULTY OF PSYCHOLOGY AND
EDUCATIONAL SCIENCES

Examining the Effect of Emotion Differentiation on Psychotherapeutic Change Throughout ACT-DL Therapy in Individuals with Early Psychosis

A multicenter randomized controlled trial

Master's thesis submitted for the
degree of Master of Science in
Master of Psychology: Theory and
Research by
Zhuoli Zheng

Supervisor: Inez Germeys, Ph.D.
In collaboration with:
Rafaël Bonnier, Ph.D.
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Summary

Psychosis is a cluster of symptoms that can be disruptive in many medical, neurodevelopmental, and psychiatric conditions (Arciniegas, 2015). According to Kimhy et al., 2016, difficulty in identifying and distinguishing emotions, which is called emotion differentiation, is one of the core problems of psychosis (Lischetzke et al., 2005). Differentiating emotions is essential to social functioning as emotions can provide important information about a particular social situation, navigate the problem, and guide the corresponding behaviours (Barrett et al., 2001). Individuals with early psychosis experience difficulties in emotion differentiation, which can, in turn, result in social dysfunction (Van Rijn et al., 2011). Thus, investigating the association between emotion differentiation and social functioning can provide insight into the development of psychosis (van Rijn et al., 2011). This thesis will investigate the effect of emotion differentiation on social functioning and negative psychotic symptoms.

We hypothesized that i) emotion differentiation will improve among individuals with early psychosis throughout the ACT-DL intervention ii) and the changes in emotion differentiation will, in turn, lead to changes in negative psychotic symptoms and social functioning among these individuals.

Data from the Experience Sampling Method (ESM), a structured self-report diary technique that assesses affect and symptoms in daily life (Myin-Germeys et al., 2018), are used for emotion differentiation. We used the Social and Occupational Functioning Scale (SOFAS) to measure social functioning and Korte Schaal voor Negative Symptomen (KSNS) to measure negative psychotic symptoms. We conducted a multilevel analysis to investigate the change in emotion differentiation over the therapy. We also used two multiple linear regression models and four simple linear regression models to examine the effect of the changes in emotion differentiation on social functioning and negative symptoms.

Our results showed significant improvement in emotion differentiation after four weeks of intervention, but only for negative affect. We cannot conclude that improving emotion differentiation can predict negative symptom reduction or social functioning improvement. The results have indicated that ACT-DL can effectively improve emotion differentiation over time, and emotion differentiation is a core underlying issue in psychosis. However, other underlying crucial problems should also be addressed to achieve a solid improvement in psychosis. These results may be used to inform future research examining emotion differentiation as an underlying mechanism along with other possible factors to understand the onset of psychosis better while advancing the treatment for individuals with UHR and FEP.

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisor Professor. Inez Myin-Germeys for giving me this unique and valuable experience to conduct my Master's thesis research at her lab. As a Master's student passionate about clinical psychology, I am grateful to have this invaluable opportunity to work on such a terrific project and get hands-on experience in clinical research.

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Approach and own contribution

In the first year of my Master's study, I finished my thesis's introduction and method sections. Before starting my thesis project, I decided to familiarize myself with the literature and jargon relevant to the project. My mentor Rafaël and Evelyne have sent me many papers on the topic of the Experience Sampling Method (ESM), Ecological Momentary Interventions (EMIs), and Acceptance and Commitment Therapy (ACT), and I have read them all. I have also made my literature search on psychosis, Ultra High Risk (UHR), First-Episode Psychosis (FEP), emotion regulation, emotion differentiation, and social functioning. After reading those papers, I wrote a literature review draft to form a narrative that led to my hypotheses and research questions. Each month, I had a supervision meeting with my mentors to go over my writing, present what I have done, and discuss any issues that have come up. After each meeting, I integrated all the feedback and researched more to construct my introduction and method sections. At the near end of the first year, I gave a presentation to present my research progress and research plan at the lab meeting in front of all the Master's thesis students, all the Ph.D. mentors, and my supervisor Professor. Myin-Germeys.

In the second year of my Master's study, my main focus was data analysis and finishing writing the whole thesis. For the data analysis part, I have developed the entire design to analyze my data to answer my research questions. After I had received all the requested data, I spent much time figuring out all the necessary code in Rstudio on my own. I had no experience in R or any programming before, but I managed to self-teach myself how to write scripts and program in R with minimal external help. It was challenging and time-consuming, but I have learned much from this experience. I wrote this entire thesis independently and incorporated my supervisor's and mentors' feedback.

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Abstract

Psychosis is a cluster of symptoms that can be disruptive in many medical, neurodevelopmental, and psychiatric conditions (Arciniegas, 2015). According to Kimhy et al., 2016, difficulty in identifying and distinguishing emotions, which is called emotion differentiation, is one of the core problems of psychosis (Lischetzke et al., 2005). Differentiating emotions is essential to social functioning as emotions can provide important information about a particular social situation, navigate the problem, and guide the corresponding behaviours (Barrett et al., 2001). Individuals with early psychosis experience difficulties in emotion differentiation, which can, in turn, result in social dysfunction (Van Rijn et al., 2011). Thus, investigating the association between emotion differentiation and social functioning can provide insight into the development of psychosis (van Rijn et al., 2011). This thesis will investigate the effect of emotion differentiation on social functioning and negative psychotic symptoms. We hypothesized that i) emotion differentiation will improve among individuals with early psychosis throughout the ACT-DL intervention ii) and the changes in emotion differentiation will, in turn, lead to changes in negative psychotic symptoms and social functioning among these individuals. Data from the Experience Sampling Method (ESM), a structured self-report diary technique that assesses affects and symptoms in daily life (Myin-Germeys et al., 2018), are used for emotion differentiation. We used the Social and Occupational Functioning Scale (SOFAS) to measure social functioning and Korte Schaal voor Negative Symptomen (KSNS) to measure negative psychotic symptoms. We conducted a multilevel analysis to investigate the change in emotion differentiation over the therapy. We also used two multiple linear regression models and four simple linear regression models to examine the effect of the changes in emotion differentiation on social functioning and negative symptoms. Our results showed significant improvement in emotion differentiation after four weeks of intervention, but only for negative affect. We cannot conclude that improving emotion differentiation can predict negative symptom reduction or social functioning improvement. The results have indicated that ACT-DL can effectively improve emotion differentiation over time, and emotion differentiation is a core underlying issue in psychosis. However, other underlying crucial problems should also be addressed to achieve a solid improvement in psychosis. These results may be used to inform future research examining emotion differentiation as an underlying mechanism along with other possible factors to understand the onset of psychosis better while advancing the treatment for individuals with UHR and FEP.

Keywords: ACT-DL, emotion differentiation, ESM, negative symptom, psychosis

1. Introduction

1.1. Psychosis

Psychosis is a cluster of symptoms that can be disruptive in many medical, neurodevelopmental, and psychiatric conditions (Arciniegas, 2015). The lifetime prevalence rate of all psychotic disorders is 3.06%, meaning that approximately 3 out of 100 people have met the diagnostic criterion of some psychotic disorder at least once worldwide (Perala et al., 2007). Psychosis is one of the leading causes of long-term disability, and it is associated with many social and economic costs for people who suffer from psychotic symptoms (Mueser & McGurk, 2004). Also, psychosis is a common feature of schizophrenia spectrum disorders, mood disorders (schizoaffective disorder), and substance use disorders (substance-induced psychotic disorder).

There are distinct phases in the development of psychosis: Ultra High Risk (UHR) and First-Episode Psychosis (FEP). UHR individuals have experienced only some milder psychotic symptoms before the onset of a psychotic episode. At the same time, FEP refers to the first time individual experiences a psychotic episode (Breitborde et al., 2009). People are at UHR condition when they meet the criteria for i) the attenuated positive symptoms (APS) syndrome; ii) the brief, limited intermittent psychotic symptoms (BLIPS) syndrome; iii) presumed genetic vulnerability (first-degree family member); and iv) declined functioning (Corcoran et al., 2010; Kimhy et al., 2016). Approximately 2/3 of people are in the UHR group before transition to FEP (Raket et al., 2020).

Psychotic symptoms are typically categorized as positive and negative, affecting people's cognitions, affects, and behaviours. Positive symptoms are false perceptions and false beliefs possessed by patients. These symptoms are seen as accurate by patients while being seen as bizarre and unacceptable by people who do not suffer from them (Fletcher & Frith, 2008). Negative symptoms, on the other hand, refer to the absence or reduction of affective, social, and behavioural expression and functioning (Lutgens et al., 2017).

According to the diagnostic classification systems of the American Psychological Association (DSM-5) and the World Health Organization (ICD-11), impaired reality testing is central to positive psychotic symptoms (Arciniegas, 2015). One example of impaired reality testing is delusions, which are fixed false beliefs that people maintain even in the face of contradictory evidence. Another example of positive symptoms is hallucinations. Hallucinations are perceptions that occur in the absence of an external stimulus. Hallucinations occur in many modalities, such as sensory, visual, or auditory (e.g., feeling touched by other people, seeing faces, and hearing the telephone, respectively). They are vivid, substantial, and perceived to be located in an external space and can happen with or without the affected people having insights into the symptoms (Arciniegas, 2015).

When it comes to negative symptoms, the domains include blunted affect (i.e., difficulty in displaying outward emotion), alogia (i.e., decreased speech), asociality (i.e., inability to engage in social interaction), anhedonia (i.e., inability to experience pleasure), and avolition (i.e., lack of motivation to engage in goal-directed behaviours) (Kirkpatrick et al., 2006). People with negative psychotic symptoms have an absence or reduced expression and normal behaviours associated with motivation compared to people without psychosis.

Thus, both positive and negative symptoms can lead to high social costs for patients and society, and psychosis disrupts people's daily living, impairs social functioning, and leads to physical illnesses (Petrakis et al., 2012). It is essential to understand the underlying mechanisms of psychosis.

According to Kimhy et al., 2016, difficulty in processing emotions is one of the core problems of psychosis. In one study, adolescents in the UHR condition have demonstrated difficulties identifying and communicating their emotions, irrespective of their intelligence scores (van Rijn et al., 2011). In another study, individuals with elevated cognitive-perceptual symptoms of schizotypal personality disorder paid significantly more attention to their

emotions than healthy controls (Berenbaum et al., 2006). Hence, investigating how people with psychosis process and manage their emotions can help to explain the underlying issue of psychosis. One way to achieve this is to examine emotion differentiation in individuals with psychosis.

1.2. Psychosis, emotion differentiation and social functioning:

Emotion differentiation refers to the individual's ability to identify, label, and represent their affective experiences in a specific way sensitive to the particular context (Lischetzke et al., 2005). It is the ability to discriminate between emotion experiences and use verbal labels to distinguish between emotions. Individuals with low emotion differentiation tend to use more global terms like "good" or "bad" to identify and label their discrete affective experiences. In contrast, individuals with high emotion differentiation are more likely to use specific terms like "anger" and "frustration" to label their experiences and make more subtle distinctions between their emotional experiences (Boden et al., 2013, pp. 961-978).

Identifying and understanding emotions is fundamental to regulating and managing emotions. Swinkels and Giuliano (1995) have proposed that the ability to differentiate emotions functions as a prerequisite for recognizing the cause of an emotion, how the emotion is expressed, how the emotion can affect others and their behaviours, and in turn leads to how to change the emotion in a way that it can elicit the wanted behaviour. Additionally, emotion differentiation is positively correlated with the ability to regulate emotions, especially for high-intensity negative emotions (Barrett et al., 2001). Also, differentiating and specifying these emotions could help decrease the intensity of these negative emotions, which functions as an emotion regulation strategy (Philippot et al., 2006).

Emotion differentiation is found to be associated with well-being, and people with a better ability to differentiate their emotions tend to report lower levels of emotional intensity,

depression, neuroticism, and a higher level of self-esteem (Erbas et al., 2014; Wilroth et al., 2019). Positive emotion differentiation is associated with more successful emotion regulation, effective coping strategies, and better recognition of others' emotions (Tugade et al., 2004; Israelashvili et al., 2019). Low emotion differentiation is linked to poorer emotion regulation and more psychopathology (Aldao et al., 2010). Subsequently, impairments in emotion differentiation are found in many psychopathologies, including psychotic disorders (Kimhy et al., 2014).

Based on the "affect-as-information perspective," Schwarz (1990) proposed two emotional states: specific and global. They both have an informational value that indicates when and how to change one's current behaviour. It is worth noting that specific emotional states (i.e., anger and sadness) are more adaptive than global emotional states (i.e., positive and negative feelings), so it is adaptive to foster the ability to differentiate specific emotions in the same category. Thus, people in both the UHR and FEP states may have difficulties in constructing their mental representations of their emotions due to the inability to differentiate between specific emotions, and these mental constructs are crucial for regulating emotions in social contexts, guiding social interactions, and adapting to ever-changing environments (van Rijn et al., 2011).

According to van Rijn and colleagues (2011), the importance of emotional processing for social functioning can be explained by Emotional Intelligence (EI) models. EI refers to "the ability to monitor one's own and other's feelings, to discriminate among them and to use this information to guide one's thinking and action" (Mayer et al., 2003, pp. 97-105). The model of EI consists of four skills: 1) the ability to perceive others and their own emotions, 2) the ability to use emotions, 3) the ability to understand the relationship between emotions and differentiate these emotions, and 4) the ability to manage and regulate other's and their own emotions (Salovey & Grewal, 2005).

A low score on EI indicates difficulties in processing emotions, and it is associated with negative social interactions in daily life (Brackett et al., 2006). Additionally, based on the models of EI, the association between the inability to regulate emotion and social dysfunction is found in both clinical and non-clinical groups. Adolescents and young adults with schizotypal traits were observed to have low scores on EI tests, and their inability to perceive and manage emotions was associated with poor social functioning (Aguirre et al., 2008).

Notably, people with psychosis also have problems in social functioning. According to a study by Stain et al. (2012), 69% of participants with psychosis have not attended any social activity in the past year, and 63.2% have shown significantly impaired social functioning. Also, 80.1% of adults with psychosis have reported loneliness and social isolation, while only 29.5% have received help regarding their social functioning (Stain et al., 2012). Additionally, there is a positive association between social dysfunction and negative psychotic symptoms, and the more impaired the social functioning, the more negative psychotic symptoms (Wittorf et al., 2008). Hence, individuals with early psychosis experience difficulties in correctly identifying and regulating their emotions, which can, in turn, result in social dysfunction (Van Rijn et al., 2011).

Thus, emotion differentiation may function as the core component of understanding the underlying mechanism of the development of psychosis. Investigating the association between emotion differentiation and social functioning can provide insight into the development of psychosis (van Rijn et al., 2011).

Altogether, literature has shown that differentiating emotions is essential to social functioning as emotions can provide important information about a particular social situation, navigate the situation, and guide the corresponding behaviours (Barrett et al., 2001). Thus, improving the ability of emotion differentiation could lead to improved social functioning (Vandercammen et al., 2014).

1.3. Measurement of emotion differentiation:

Measures of emotion differentiation assess people's ability to understand their affective experiences and their knowledge level of their emotions at discrete time points (Lindquist & Barrett, 2008). One way to measure people's ability to differentiate emotions in real life is through Ecological Momentary Interventions (EMIs). EMIs are interventions provided to people in their daily life, real-time, and natural settings (Heron & Smyth, 2010), enabling interventions to happen outside the regular office setting. Practicing these skills in actual experiences and real-world settings increases the ability to implement them. It allows clinicians to study the real-time experience in everyday environments instead of relying on clients' self-reflections on their perceived behaviours and feelings (Myin-Germeys et al., 2018) and understand better how their clients' symptoms manifest (Heron & Smyth, 2010).

We will calculate the Intra-Class Coefficient (ICC) between emotion words to assess emotion differentiation. In this thesis, we will group emotion words into two groups: positive (cheerful, relaxed, and satisfied) and negative (insecure, anxious, irritated, and gloomy). Within each group, a minor association between positive or negative words indicates a more significant distinction within that affect category, indicating higher emotion differentiation (Thompson et al., 2021). For example, "insecure," "anxious," "irritated," and "gloomy" are all categorized as negative affect words, and people with difficulty differentiating emotions will rate these words very similarly. Consequently, these words will have a high correlation, indicating low emotion differentiation and the inability to tell each affect apart in the same category. The inability to differentiate emotions that are in the same category can be an indicator of social dysfunction.

This thesis will investigate the effect of emotion differentiation on social functioning improvement and negative symptom reduction.

1.4. Psychosis and treatments:

Early Interventions in Psychosis (EIP) are crucial in intervening in the transition from UHR to FEP. These interventions focus on identifying individuals at risk for developing psychosis and provide them with treatment and guidance. These interventions include medication and individual cognitive behavioural therapy, outreach therapy and social assistance. Hence, EIP can effectively prevent and delay the transition from the UHR to the FEP condition (Stafford et al., 2013).

Acceptance and Commitment Therapy (ACT), as a third-wave behavioural therapy, aims to enhance an individual's psychological flexibility. Psychological flexibility consists of two parts, acceptance, which refers to the ability to realize and accept one's undesired feelings, thoughts, and experiences without judgements (acceptance), and commitment, which refers to engaging in goal-directed actions in the face of difficulties (Hayes et al., 2006; Bond et al., 2011). Experiential avoidance, as a core component of ACT, refers to the unwillingness to stay in an undesired experience (Chawla & Ostafin, 2007), and it is associated with distress associated with hallucinations, depression, anxiety, and stress in individuals with psychotic disorders (Varese et al., 2016; Perry et al., 2021). Hence, ACT teaches individuals to use acceptance to replace experiential avoidance while simultaneously helping individuals transfer values and goals into committed actions.

An ACT-based EMI called 'ACT in Daily Life' (ACT-DL) is a new mobile health (mHealth) treatment based on ACT. ACT-DL is an ACT-based EMI where ACT is provided in daily life in the real world. It aims to help patients transfer what they have learned from face-to-face ACT sessions into real-life practice (Myin-Germeys et al., 2016). ACT was as effective as CBT in treating anxiety, depression, addiction, and somatic disorders (A-Tjak et al., 2015). However, like most psychotherapies, ACT is mainly administered in the therapist's office, and this office-based approach may fail to produce large effect sizes (Veehof et al., 2011). As an

alternative, the daily implementation of mobile devices to deliver healthcare services and health communication has become more popular (Free et al., 2013). ACT-DL requires patients to engage in the active practice of ACT principles in their daily life in addition to their regular ACT sessions. This approach is a mHealth intervention based on ESM, which requires patients to apply ACT techniques in real life in real time for their current experiences.

During the ACT-DL intervention period, patients will receive a beep eight times a day on their mobile app that prompts them to assess their current mood, symptoms, experiences, and activities in a short questionnaire, which helps patients to increase their awareness of their current state at the present moment (Vaessen et al., 2019). Patients can activate an ACT exercise anytime they need help processing unwanted thoughts or feelings (Vaessen et al., 2019). There are six core components of ACT (acceptance, cognitive defusion, self as context, contact with the present moment, values, and committed action). Participants are asked to do ACT exercises every day in the morning, afternoon, and evening on the component covered in that specific week (Vaessen et al., 2019). Once the training on all the components is over, the mobile app exercise will cover everything they have learned to assist patients in flexibly changing their mindsets in different contexts, especially in challenging contexts (Vaessen et al., 2019).

Considering the philosophical roots of ACT in functional contextualism, which focuses on the usefulness of the behaviour, and the relevance of the context of where the behaviour is happening, it indeed matches the mHealth approach as ACT-DL requires patients to implement the ACT techniques into context in their real life (Vaessen et al., 2019).

Hence, ACT emphasizes the usefulness of thought and behaviour in a particular context (Vaessen et al., 2019). This personalized mobile-based intervention can help patients to incorporate what they have learned from ACT sessions into their real life. The consistent questionnaires require patients to rate their emotions, while the available techniques assist

patients in dealing with a specific moment in their daily life. This helps improve patients' awareness of their current state and context and better differentiate their emotions over time.

1.5. Hypotheses:

We hypothesized that i) emotion differentiation will improve among individuals with early psychosis throughout the AC-DL intervention and ii) the changes in emotion differentiation can, in turn, lead to changes in negative psychotic symptoms and social functioning among these individuals.

1.6. Predictions:

We predicted that i) emotion differentiation among individuals with early psychosis will be improved throughout the intervention and ii) this improved emotion differentiation can predict the reduction in negative psychotic symptoms and the improvement in social functioning among these individuals.

Material and Methods:

2.1. Setting:

The current study is a part of the INTERACT trial (Reininghaus et al., 2019), which is a single-blind, multicenter, randomized controlled trial that investigated the effectiveness of ACT-DL in treating early psychosis. The study recruitment started in November 2016, and the outcome assessment ended in June 2020. The INTERACT trial aimed to investigate the efficacy of ACT-DL, a momentary ecological intervention, in individuals at the UHR or FEP state. It was the first study in the field to test the effectiveness of ACT-DL in individuals with early psychosis, and the results can help to advance the treatment of these people. This thesis will only use the ESM data gathered from the mobile app *PsyMate* in the treatment group because

only participants in the treatment group were asked to record the ESM data on *PsyMate*. We will only include an assessment at baseline (before randomization) and post-intervention (after the intervention period). The original INTERACT trial also assessed outcomes at 6-month and 12-month follow-ups after the intervention was over, but this thesis will not consider follow-up results. The first research question will use assessment time (the week number) as the predictor variable and emotion differentiation as the outcome variable. The second research question will use emotion differentiation as the predictor variable and scores on social functioning and negative psychotic symptoms as the outcome variables. The INTERACT trial was registered in the Netherlands on September 26, 2013, and the registration ID is NTR4252 (Reininghaus et al., 2019).

2.2. Participants:

Participants were recruited from 5 secondary mental health services regions in Belgium and the Netherlands. Participants were recruited in the following secondary mental health services at clinical sites of five centres: (1) Amsterdam (Academic Medical Centre, Arkin Basis GGZ), (2) The Hague (Parnassia/PsyQ), (3) Maastricht/Eindhoven (Mondriaan, Virenze, GGZE) (all in the Netherlands), (4) Flemish-Brabant (Leuven (UPC KU Leuven), Antwerp (VDIP), Diest (Sint-Annendael), Mortsel (PCM)), and (5) East/West Flanders (Brugge (OLV), Melle (Karus), Sint Niklaas (VDIP)) (all in Belgium). To meet the inclusion criteria, participants have to be between 15 to 65 years old and have been clinically diagnosed with an Ultra High Risk (UHR) status (never used antipsychotic medication for psychotic symptoms) or a First-Episode Psychosis (FEP) status (onset within last three years). Also, participants were required to have sufficient Dutch ability to receive intervention, follow instructions, and provide written informed consent. The current study will focus on ACT-DL+Treatment as Usual (TAU) participants. All 71 participants in the treatment group were included.

2.3. Selection Procedure

After completing informed consent, full eligibility assessment, and assessment of all outcome measures, eligible participants were randomly allocated at a 50:50 ratio to ACT-DL+ TAU as the treatment condition or TAU as the control condition. 71/148 eligible participants were randomly assigned into the ACT-DL+TAU group, with 49% being females and 48% in the FEP condition (mean age=25, SD=6). Participants were randomized through a computer-generated sequence, and this randomization was conducted at the level of the individual participant by an independent researcher. Block randomization was performed in blocks of six participants (with stratification for the five centres mentioned above) and two groups of UHR and FEP (with an expectation to include a 50:50 ratio of HUR and FEP in the sample). The researchers responsible for assessing the outcomes and conducting the statistical analyses were blind to the treatment allocation in this single-blind study. A contact person oversaw the procedure, and any violation of blindness would result in a new researcher continuing the assessments (Reininghaus et al., 2019).

2.4. Interventions:

Participants were randomly assigned to either the TAU group or the ACT-DL+TAU group. Participants in the treatment condition (ACT-DL+TAU) would receive an eight-week ACT-DL in addition to TAU, which was the treatment they previously received before the start of the study, with one exception of manualized CBTp. Participants were allowed to request the termination of the ACT-DL treatment at any time without any negative consequences. A trained clinical administered the manualized ACT-DL face-to-face for eight sessions, each lasting 45 to 60 minutes. Among the eight sessions, the first session would be for psychoeducation, and the second to the seventh sessions were designed for people with psychosis. It targeted the six core components of ACT (creative hopelessness, acceptance, cognitive defusion, self as context

& contact with the present moment, values, and committed action) (Vaessen et al., 2019), and the last session was for integrating and reviewing all the six components. Participants in the treatment group were also asked to use a smartphone-based app called *PsyMate* to apply the skills that they had learned during the sessions, and this involved completing a questionnaire on their current mood and psychotic experiences eight times a day and three days a week for seven weeks (excluding the first week of psychoeducation) to increase their awareness of their psychological state at the moment. Participants would lose access to the app once the therapy ended (Reininghaus et al., 2019).

2.5. Measurements of independent variables:

2.5.1. Demographics:

The eligibility criterion of UHR and FEP was assessed by the Comprehensive Assessment of At-Risk Mental State (CAARMS) (Yung et al., 2005). Eligible participants were asked to select between either "male" or "female" for their gender and wrote down their age on a self-report demographics questionnaire. This thesis project will only not use any specific data from the CAARMS, and it will not take age or gender into consideration.

2.5.2. Emotion differentiation:

Emotion differentiation was measured using the intraclass correlation coefficient (ICC) with the ESM data from the *PsyMate* app. The *PsyMate* app is a platform to keep track of people's thoughts, feelings, experiences, and behaviours. Participants in the ACT-DL group were required to download the *PsyMate* app. The app beeps eight times a day and three days a week for seven weeks over the experiment. After each beep, it prompts individuals to fill out a short questionnaire to rate their current positive and negative affect. For each week, participants would receive 24 beeps with the same questionnaire. Within the questionnaire, the participants would rate the statements "I feel relaxed," "I feel satisfied," "I feel insecure," "I feel anxious,"

"I feel irritated," "I feel gloomy," "I feel paranoid," "I feel unreal," "I hear voices," "I see things," and "I feel peace." The changes in participants' ratings on these statements over the 7-week intervention indicate their emotional differentiation changes. For example, a slight change in the ratings of the same statement will indicate a slight change in that participant's ability to differentiate emotions. In contrast, a significant change score will indicate more changes in that participant's emotion differentiation skill.

This study will use the change score on each participant's ratings on these same statements over the 7-week intervention within the positive affect group (relaxed and satisfied) and the negative affect group (insecure, anxious, irritated, and gloomy) to examine participants' emotional differentiation. The statements "I feel paranoid," "I feel unreal," "I hear voices," "I see things," and "I feel peace" are categorized as pathology. This thesis project will focus on the positive and negative affects only. The change scores will be analyzed through the intraclass correlation coefficient (ICC) for each week. ICC describes how strongly each unit (each affect in this case) correlates with/ resembles each other within the same (affect) group. Within each affect group, we will calculate the ICC as the indicator of emotion differentiation. For example, in the positive affect group, ICC will indicate how much the affect "relaxed" correlates with the affect "satisfied." ICCs for the positive and negative affect groups will be calculated separately and analyzed independently, but both groups' procedures and principles remain the same.

A small ICC means that all the affects from that specific affect group barely correlate with each other, indicating a solid emotion differentiation, and the participant has no issues in distinguishing these affects. On the other hand, a large ICC means that the affect in the same category is highly correlated with each other and indicates that the participants cannot differentiate their emotions. For straightforward interpretation, we will transform the ICC to 1-ICC so that a higher score reflects more emotion differentiation. The entire therapy was eight

weeks, but the ESM data from the *PsyMate* were only recorded for seven weeks, so this thesis would focus on the 7-week ESM data when calculating the ICCs. All the participants in the ACT-DL+TAU group were included regardless of the completion of their ESM data. We will calculate the ICC for each week. Then we will analyze the overall trend of ICC over the seven weeks and the change of ICC between week one and all the other weeks in both positive and negative affect groups, respectively. Lastly, we will compare the pre-intervention (week one) with the post-intervention (week seven) to examine the treatment effect of ACT-DL+TAU on emotion differentiation.

2.6. Measurements of outcome variables:

2.6.1. Negative symptoms:

Negative symptoms were measured using the Dutch version of the Brief Negative Symptom Scale (BNSS) (Kirkpatrick et al., 2011), which is called the "Korte Schaal voor Negative Symptomen" (KSNS) (Seelen-de Lang et al., 2020). It includes six domains—anhedonia, asociality, avolition, blunted affect, alogia, and distress. Each subscale has 13 items, and participants were asked to rate each item on a 7-point Likert scale, with 0 being no impairment and 6 being severe deficit. The total score is the sum of the six subscales, ranging from 0 to 78. The higher the total score, the more severe the negative symptoms. This thesis will focus on the data of KSNS at the baseline (pre-intervention) and post-intervention (right after the intervention).

2.6.2. Social functioning:

Social functioning was measured using the Social and Occupational Functioning Scale (SOFAS), and it is not directly influenced by the overall severity of the participant's psychological symptoms (Morosini et al., 2000). The SOFAS is rated continuously from 1

(severe malfunctioning) to 100 (superior functioning). The higher the score is, the better the social functioning is. This thesis will focus on the data of SOFAS at the baseline (measured in the previous year) and post-intervention (measured in the past two weeks).

2.7. Data analysis

2.7.1. Research question one:

First, this thesis examines whether emotion differentiation (ICC) has been improved throughout ACT-DL therapy. ICC scores were calculated each week for both the positive and negative affect groups, resulting in 7 ICCs for the positive affect group and 7 ICCs for the negative affect group in the seven weeks. ICC data were grouped by each week, and the summary statistics for the mean and standard deviation were calculated for that specific week for the positive and negative affect groups, respectively. I did a descriptive statistical analysis of all the ICC scores to explore the data. I visualized the data with box plots for positive and negative affect groups on ICC mean scores for the seven weeks. I also created a mean plot for each affect group to show the overall trend in ICC data over the seven weeks. I also ran a test to identify outliers. To check the normality assumption, the Shapiro test was performed for the positive and negative affect groups, respectively, from week one to week seven. Levene's test was used to check the homogeneity of variance. The assumptions were considered to be not violated if the p-values were above 0.05. After calculating the ICC for each affect group each week, we examined the change in ICC scores over the seven weeks of intervention to examine if participants were more likely to differentiate their emotions over time. To achieve this, I ran a multilevel analysis to investigate whether or not the time point (number of the week) can predict the change in ICC scores over time. I also used a multilevel model to test the effects of the different assessment times. The above procedure was done for both positive and negative affect groups. The R script for calculating ICC scores can be found in Appendix 1, "R script

for ICC," and the R script for running the multilevel analysis in Appendix 2, "R script for Multilevel Analysis." A p-value below 0.05 will be considered statistically significant. For straightforward interpretation, we will transform the ICC to 1-ICC so that a higher score reflects more emotion differentiation.

2.7.2. Research question two:

Secondly, this thesis aims to investigate the effect of emotion differentiation (ICC) on social functioning (SOFAS) improvement and symptom (KSNS) reduction. I first ran a Reliable Change Index (RCI) analysis independently on all four variables (ICC scores for the positive affect group, ICC scores for the negative affect group, SOFAS, and KSNS). The first reason for running RCI is to evaluate if the change in each variable's score over time is statistically significant and not due to random measurement error. The second reason to conduct RCI is to convert all four variables (ICC scores for the positive affect group, ICC scores for the negative affect group, SOFAS, and KSNS) into a standardized index score that indicates change over time, which is more suitable for the analysis of this research question. This process resulted in four RCI scores for each participant. Afterwards, I used the RCI scores to perform the linear regression analysis to examine the effect of emotion differentiation on social functioning and negative symptoms, respectively. I first created scatter metrics on the entire dataset with all four variables and then four separate scatter plots (positive affect group with SOFAS, positive affect group with KSNS, negative affect group with SOFAS, and negative affect group with KSNS, respectively) to visualize the data. After the graphs were done, I performed two multiple linear regression models and four simple linear regression models to examine the effect of emotion differentiation on social functioning and negative symptoms. The two multiple linear regression models had two predictor variables (ICC score for the positive affect group and ICC score for the negative affect group) and one outcome variable (social functioning or negative symptoms). The multiple linear regression models examined if the ICC scores (combining all the ICC scores

from positive and negative affect groups) can predict the changes in social functioning and negative symptoms, respectively. The four simple linear regression models had one predictor variable (either ICC score for the positive affect group or ICC score for the negative affect group) and one outcome variable (either social functioning or negative symptoms). The simple linear regression models examined if the ICC score for each affect group independently can predict the changes in social functioning and negative symptoms, respectively. Hence, the four simple linear regression models are testing 1) whether or not the change in ICC scores for the positive affect group can predict the change in social functioning, 2) whether or not the change in ICC scores for the positive affect group can predict the change in negative symptoms, 3) whether or not the change in ICC scores for negative affect group can predict the change in social functioning, and 4) whether or not the change in ICC scores for negative affect group can predict the change in negative symptoms.

The R script for calculating RCI scores can be found in Appendix 3, "R script for RCI," and the R script for running the linear regression models can be found in Appendix 4, "R script for linear regression." A p-value below 0.05 will be considered statistically significant. For straightforward interpretation, we will transform the ICC to 1-ICC so that a higher score reflects more emotion differentiation.

3. Results

3.1. Research Question 1

Seventy-one participants from the treatment group (ACT-DL+TAU) who were diagnosed with UHR or FEP were included in the study. The predictor variable is assessment time (the week number), and the outcome variable is emotion differentiation (1-ICC scores). It aims to investigate whether or not emotion differentiation will improve over the seven weeks of intervention (ACT-DL+TAU).

3.1.1. ICC scores

Table 1: *Descriptive Statistics for 1-ICC scores for the Positive Affect group as a Function of the Week*

Week	*N*	*Mean*	*Median*	*SD*	*Min*	*Max*
1	37	0.78	0.682	0.38	0.192	1.5
2	31	0.722	0.765	0.391	0.101	1.5
3	31	0.74	0.679	0.348	0.224	1.333
4	30	0.732	0.676	0.331	0.029	1.423
5	25	0.793	0.739	0.311	0.155	1.432
6	37	0.78	0.682	0.38	0.192	1.5
7	31	0.722	0.765	0.391	0.101	1.5

Note. See *Figure 1*. This figure shows the boxplot of the 1-ICC scores for the positive affect group across the seven weeks, and each dot represents a participant's 1-ICC score at that specific week.

These are the mean 1-ICC scores for positive affect for each week from week one to week seven. 1-ICC value is considered poor for below 0.50, moderate between 0.50 and 0.74, good between 0.75 and 0.90, and excellent for above 0.90. 4 out of 7 of the 1-ICC scores are considered moderate, and 3 out of 7 of the 1-ICC scores are considered good.

Figure 1: Boxplot of 1-ICC scores of 7 weeks for the positive affect group

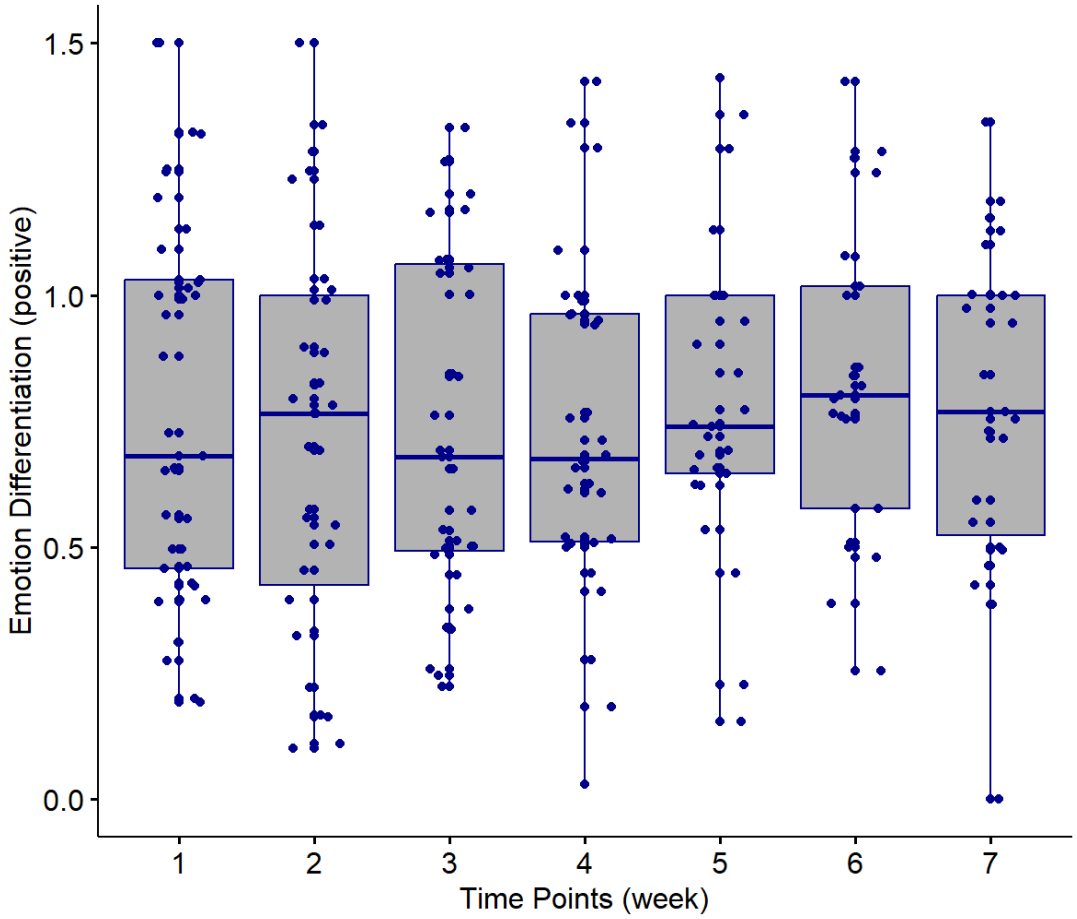


Table 2: *Descriptive Statistics for 1-ICC scores for the Negative Affect Group as a Function of the Week*

Week	***N***	***Mean***	***Median***	***SD***	***Min***	***Max***
1	37	0.729	0.739	0.295	0.109	1.165
2	31	0.791	0.83	0.297	0.098	1.258
3	31	0.837	0.756	0.267	0.301	1.319
4	30	0.884	0.964	0.296	0	1.333
5	25	0.941	0.996	0.228	0.518	1.317
6	21	0.914	0.931	0.188	0.593	1.308
7	23	0.944	1	0.272	0.35	1.333

Note. See *Figure 2.* This figure shows the boxplot of the 1-ICC scores for the negative affect group across the seven weeks, and each dot represents a participant's 1-ICC score at that specific week.

These are the mean 1-ICC scores for negative affect for each week from week one to week seven. 1-ICC value is considered poor for below 0.50, moderate between 0.50 and 0.74, good between 0.75 and 0.90, and excellent for above 0.90. 1 out of 7 of the 1-ICC scores are considered moderate, 3 out of 7 of the 1-ICC scores are considered good, and 3 out of 7 of the 1-ICC scores are considered excellent.

Figure 2: Boxplot of 1-ICC scores of 7 weeks for the negative affect group

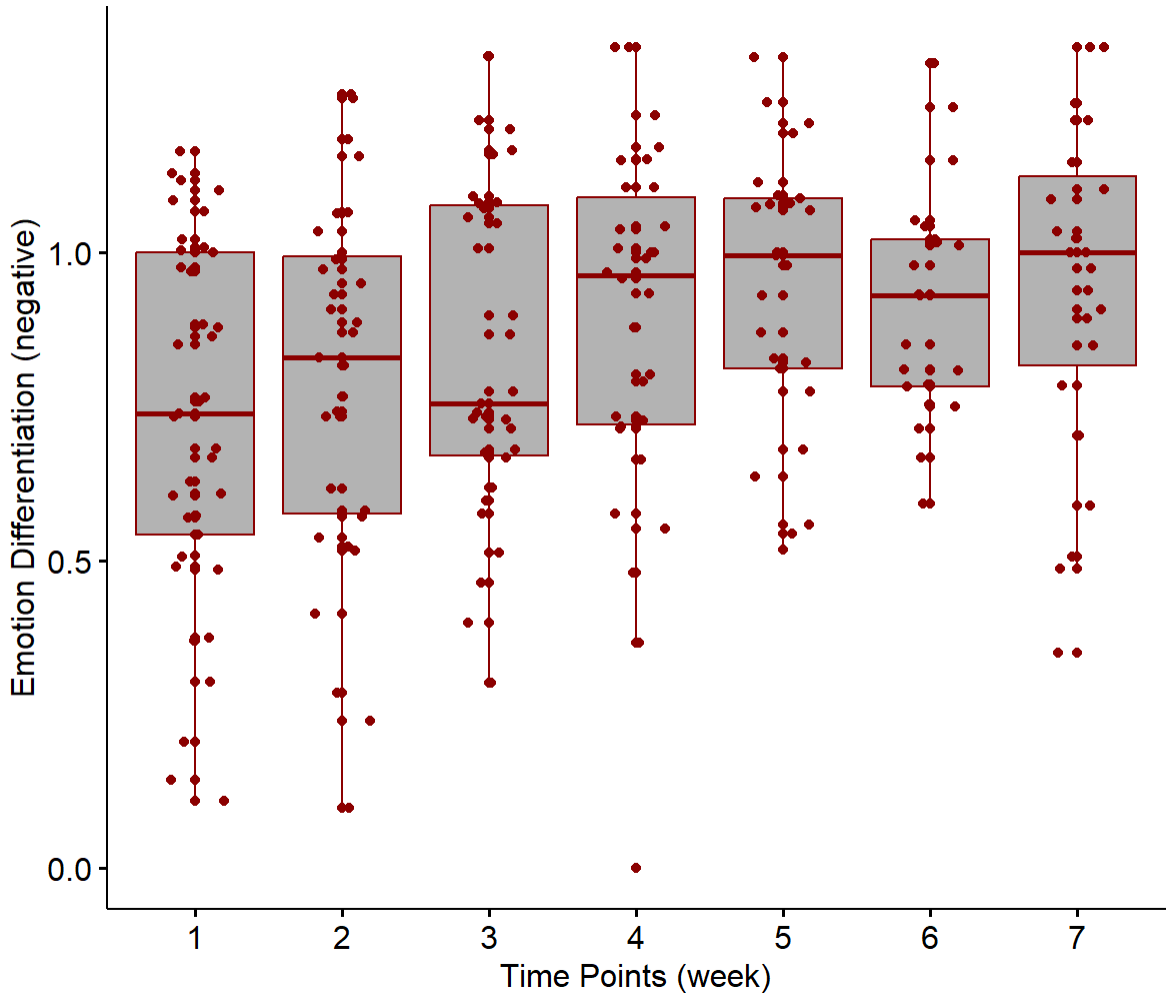


Table 3: *Multi-level Model for Positive Affect 1-ICC Scores*

Effect	***Estimate***	***Standard Error***	***df***	***T-value***	***P-value***
(Intercept)	0.791	0.056	146.282	13.948	<2e-16***
Week 2	-0.053	0.072	157.698	-0.742	0.459
Week 3	-0.025	0.072	158.047	-0.345	0.731
Week 4	-0.026	0.073	156.980	-0.359	0.720
Week 5	-0.002	0.077	158.970	-0.038	0.970
Week 6	0.031	0.081	158.116	0.386	0.700
Week 7	0.014	0.079	158.903	0.178	0.859

Note. See Figure 3. This figure shows the mean plot of the 1-ICC scores for the positive affect group across the seven weeks, and each dot represents a participant's 1-ICC score at that specific week.

This multi-level model examines whether or not the assessment time (the week number) can predict the changes in 1-ICC scores over time and whether or not the change in 1-ICC scores from each week compared with week one (intercept) is statistically significant in the positive affect group. The results show no significant change in 1-ICC scores over seven weeks compared with week one in the positive affect group.

Figure 3: Mean plot of 1-ICC scores of 7 weeks for the positive affect group

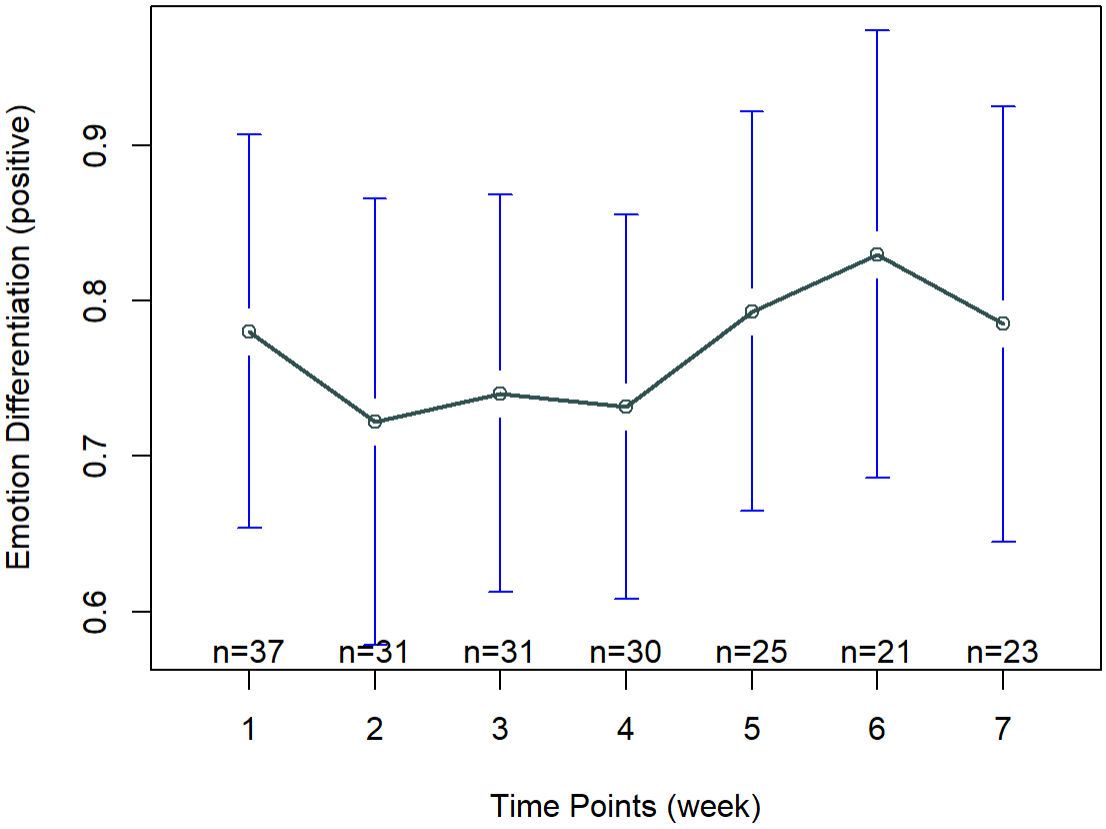


Table 4: *Multi-level Model for Negative Affect 1-ICC Scores*

Effect	***Estimate***	***Standard Error***	***df***	***T-value***	***P-value***
(Intercept)	0.731	0.043	185.469	16.891	2e-16***
Week 2	0.066	0.061	164.473	1.083	0.280
Week 3	0.106	0.061	165.108	1.722	0.086 .
Week 4	0.184	0.062	164.676	2.937	0.003**
Week 5	0.198	0.065	167.302	3.022	0.002**
Week 6	0.173	0.069	168.228	2.500	0.013*
Week 7	0.212	0.067	168.387	3.147	0.001**

Note. See Figure 4. This figure shows the mean plot of the 1-ICC scores for the negative affect group across the seven weeks, and each dot represents a participant's 1-ICC score at that specific week.

This multi-level model examines whether or not the assessment time (the week number) can predict the changes in 1-ICC scores over time and whether or not the change in 1-ICC scores from each week compared with week one (intercept) is statistically significant in the negative affect group. The results show significant changes in 1-ICC scores from week four to week seven compared with week one in the positive affect group.

Figure 4: Mean plot of 1-ICC scores of 7 weeks for the negative affect group

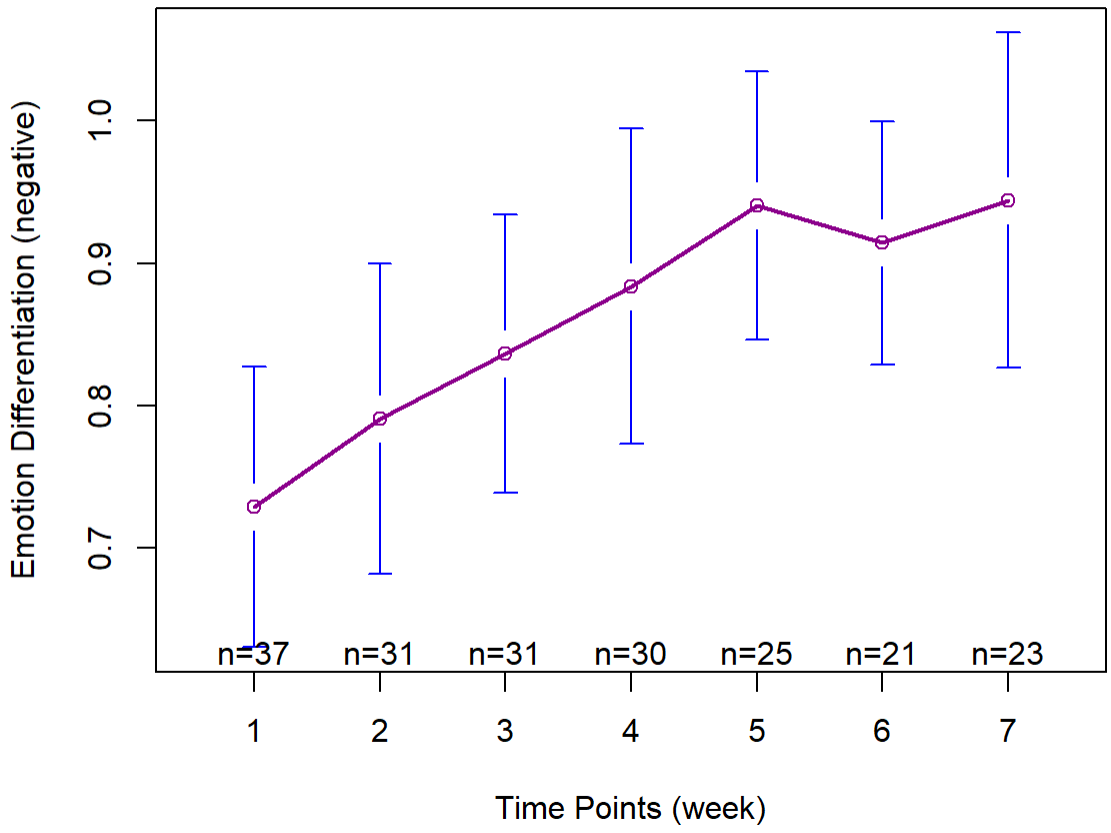


Table 5: *Type III ANOVA Model.*

Effect	***Sum of Squares***	***Mean Square***	***Dfn***	***Dfd***	***F-value***	***P-value***
1-ICC changes of positive affect group over 7 weeks	0.119	0.019	6	153.84	0.2386	0.9631
1-ICC changes of negative affect group over 7 weeks	1.114	0.185	6	163.23	2.959	0.009**

This Type III ANOVA model shows no significant change in 1-ICC scores in the positive affect group over seven weeks. Significant changes in 1-ICC scores in the negative affect group over seven weeks indicate that assessment time can predict the changes in 1-ICC scores over time in the negative affect group but not in the positive affect group.

3.1.2. Assumption Checking

The normality assumption is met in the positive affect group as residuals appear normally distributed (p=0.071). The normality assumption is violated as the non-normality of residuals is detected in the negative affect group (p=0.040). The assumption of homoscedasticity is met, and there is no clear evidence for different variances across groups (Bartlett Test, p=0.722 and p=0.352, for positive and negative affect groups, respectively).

3.2. Research Question 2

Seventy-one participants from the treatment group (ACT-DL+TAU) who were diagnosed with UHR or FEP were included in the study. The predictor variable is emotion differentiation (1-ICC scores), and the outcome variables are negative symptoms (KSNS) and social functioning (SOFAS). It aims to investigate whether or not the improvement in emotion differentiation can predict the reduction in negative symptoms and the improvement in social functioning.

3.2.1. Multiple linear regression

Table 6: *Multiple Linear Regression for Psychotic Symptoms*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	-0.864	0.297	-2.905	0.010*	-1.499	0.230
RCI score of Positive Affect	-0.271	0.135	-2.003	0.063	-0.559	0.017
RCI score of Negative Affect	0.048	0.115	0.420	0.680	-0.197	0.293

Multiple linear regression was conducted to examine if ICC scores (combining positive and negative affect groups as two predictors) can predict the changes in negative symptoms (outcome variable). The results show that none of the p-values are significant, meaning that ICC scores from neither positive nor negative affect groups cannot predict the change in negative symptoms.

Table 7: *Multiple Regression for Social Functioning*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	2.043	0.459	4.444	0.000***	1.063	3.023
RCI score of Positive Affect	-0.361	0.209	-1.730	0.104	-0.807	0.084
RCI score of Negative Affect	-0.117	0.177	-0.661	0.518	-0.496	0.261

Multiple linear regression was conducted to examine if ICC scores (combining positive and negative affect groups as two predictors) can predict the changes in social functioning (outcome variable). The results show that none of the p-values are significant, meaning that ICC scores from neither positive nor negative affect groups cannot predict the change in social functioning.

3.2.2. Simple linear regression

Table 8: *Simple Regression for Negative Symptoms in the Positive Affect Group*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	-0.809	0.260	-3.112	0.006**	-1.361	-0.258
RCI score of Positive Affect	-0.259	0.128	-2.011	0.061	-0.531	0.014

Note. See *Figure 5*. This figure visually demonstrates the association between emotion differentiation and negative symptoms in the positive affect group.

A simple linear regression was conducted to examine whether or not the change in ICC scores for the positive affect group can predict the change in negative symptoms. The result has shown a non-significant p-value, meaning that changes in emotion differentiation cannot predict the changes in negative symptoms in the positive affect group.

Figure 5: Simple regression model of emotion differentiation and negative symptoms in the positive affect group

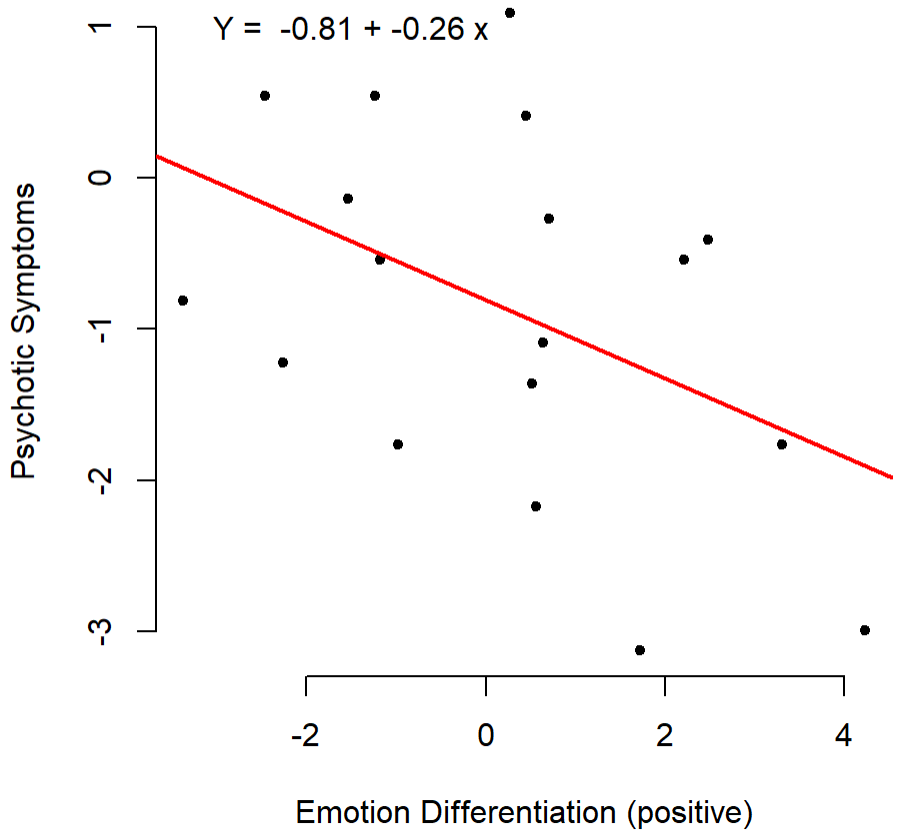


Table 9: *Simple Regression for Negative Symptoms in the Negative Affect Group*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	-0.867	0.324	-2.671	0.016*	-1.555	-0.179
RCI score of Negative Affect	-0.001	0.122	-0.010	0.992	-0.261	0. 258

Note. See *Figure 6.* This figure visually demonstrates the association between emotion differentiation and negative symptoms in the negative affect group.

A simple linear regression was conducted to examine whether or not the change in ICC scores for the negative affect group can predict the change in negative symptoms. The result has shown a non-significant p-value, meaning that changes in emotion differentiation cannot predict the changes in negative symptoms in the negative affect group.

Figure 6: Simple regression model of emotion differentiation and negative symptoms in the negative affect group

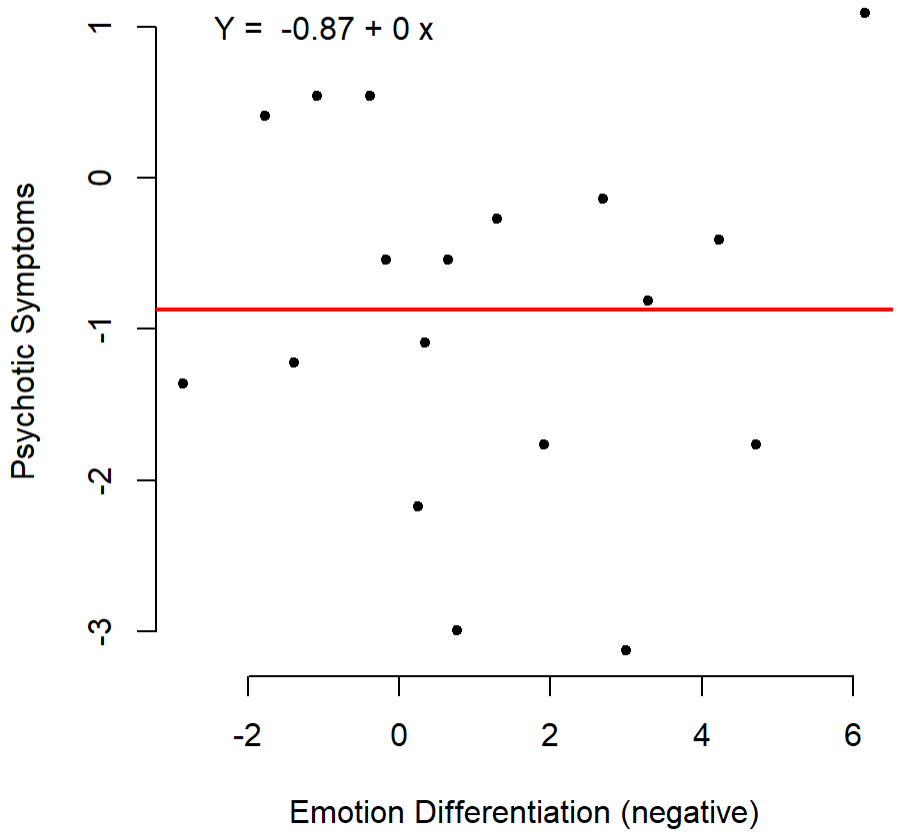


Table 10: *Simple Regression for Social Functioning in the Positive Affect Group*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	1.908	0.405	4.712	0.000***	1.050	2.767
RCI score of Positive Affect	-0.391	0.200	-1.951	0.068	-0.816	0.033

Note. See *Figure 7.* This figure visually demonstrates the association between emotion differentiation and social functioning in the positive affect group.

A simple linear regression was conducted to examine whether or not the change in ICC scores for the positive affect group can predict the change in social functioning. The result has shown a non-significant p-value, meaning that changes in emotion differentiation cannot predict the changes in social functioning in the positive affect group.

Figure 7: Simple regression model of emotion differentiation and social functioning in the positive affect group

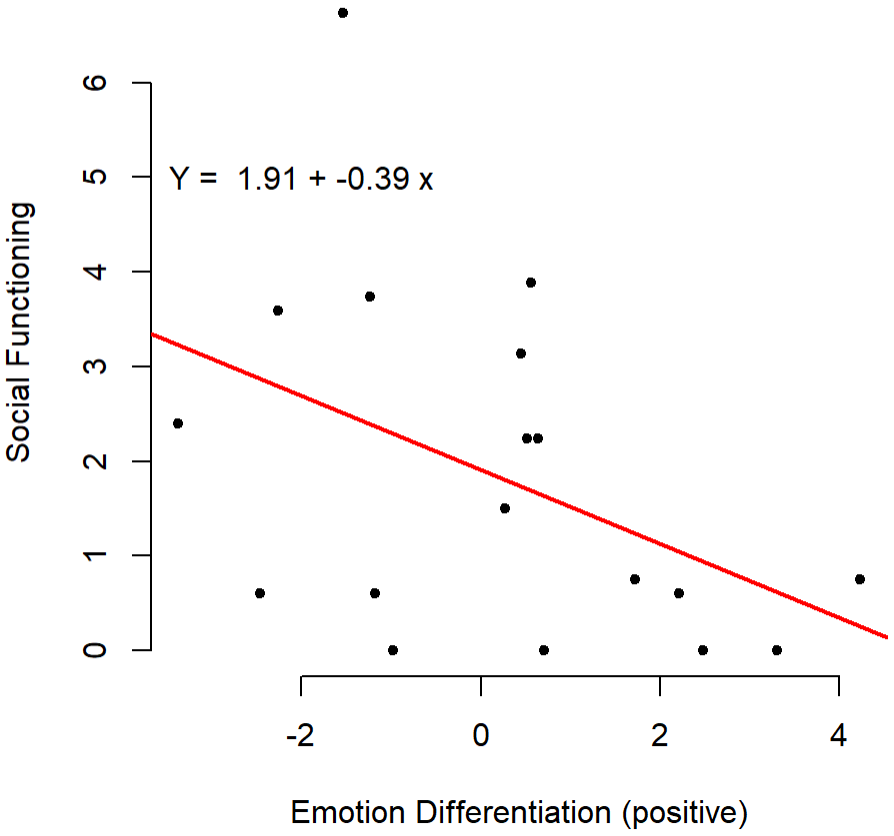


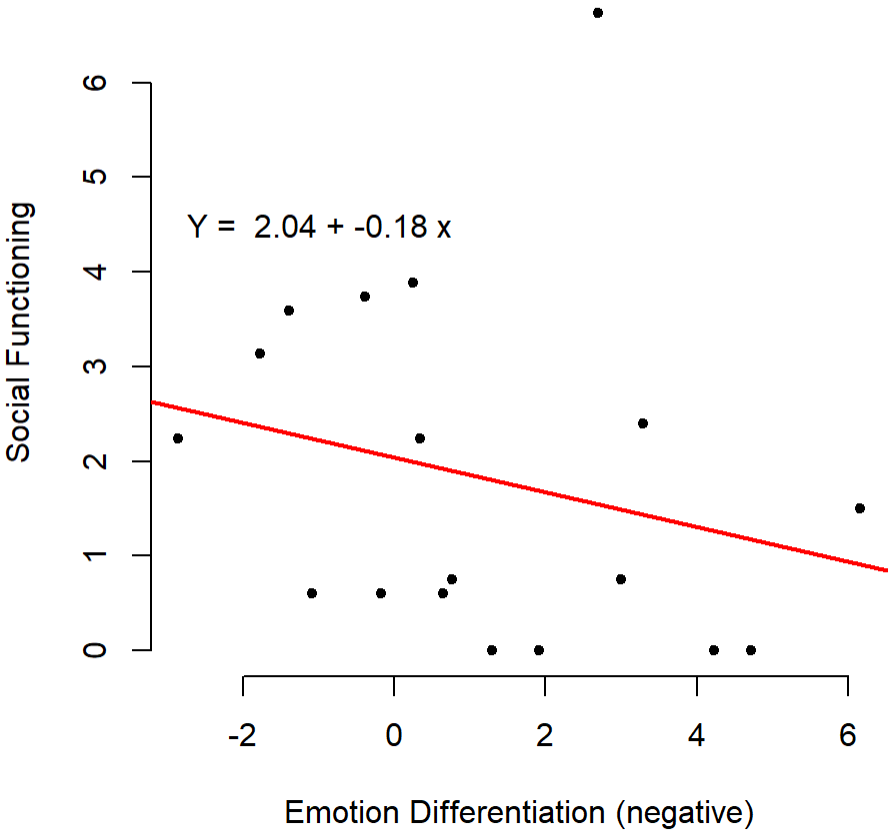
Table 11: *Simple Regression for Social Functioning in the Negative Affect Group*

Effect	***Estimate***	***Standard Error***	***T-value***	***P-value***	***2.5%***	***97.5%***
(intercept)	2.040	0.487	4.184	0.000***	1.006	3.073
RCI score of Negative Affect	-0.183	0.184	-0.997	0.333	-0.573	0.206

Note. See *Figure 8.* This figure visually demonstrates the association between emotion differentiation and social functioning in the negative affect group.

A simple linear regression was conducted to examine whether or not the change in ICC scores for the negative affect group can predict the change in social functioning. The result has shown a non-significant p-value, meaning that changes in emotion differentiation cannot predict the changes in social functioning in the negative affect group.

Figure 8: Simple regression model of emotion differentiation and social functioning in the negative affect group



4. Discussion

The two primary purposes of the current study were to 1) examine whether or not ACT-DL+TAU therapy could increase emotion differentiation for positive affect and negative affect over the eight-week therapy in individuals with early psychosis; 2) test whether or not the changes in emotion differentiation can, in turn, predict the changes in social functioning and negative psychotic symptoms among these individuals. We hypothesized that participants in the ACT-DL+TAU group would show increased emotion differentiation for both positive and negative affect throughout the therapy. We also hypothesized that this improved emotion differentiation could predict social functioning improvement and negative psychotic symptom reduction in these participants, suggesting that difficulties in emotion differentiation might be linked to social dysfunction and psychopathology in psychosis.

We found significant changes in emotion differentiation from week four to week seven compared to week one, but only in the negative affect group. This means that the treatment effect of ACT-DL only starts to be significant after four weeks into the intervention. There was no statistically significant change in emotion differentiation between pre and post-intervention or between any week and week one overall for positive affect. The results showed that ACT-DL was more effective among negative than positive affects and might target negative affects more. ACT-DL is designed to focus more on teaching people how to cope with difficult emotions; consequently, there are more therapeutic changes on negative affects, and people who received the intervention become more aware of their negative affects over time and are more equipped to deal with those negative ones than positive ones. Thus, we conclude that ACT-DL+TAU therapy can improve emotion differentiation in individuals with early psychosis. However, this improvement is only significant for negative affects but not positive ones and only after four weeks into the intervention.

For the second hypothesis, we did not find any significant result. However, when visually examining the graphs of the association between the changes in emotion differentiation and negative symptom reduction and social functioning improvement, there is a correlation; it is not statistically significant. Thus, we cannot conclude that improving emotion differentiation can, in turn, help to improve social functioning and reduce negative symptoms among people with early psychosis.

This thesis project has found that ACT-DL is effective in helping psychotic patients improve their ability to differentiate and be more aware of their emotions. This functions as the first step to improving psychotic symptoms. Although difficulty in emotion differentiation is a core underlying issue in psychosis, improving emotion differentiation alone is not enough to see a significant improvement in social functioning and a reduction in negative symptoms. Other underlying issues also need to be addressed and targeted to see an overall improvement in psychosis.

4.1. Limitations

When analyzing the findings about the results of the current study, some limitations could impact the results. First, although we have a sample size of 71 participants, only 22 participants had at least six weeks of ESM data to test the hypotheses. Among these 22 participants, all of them had missing data. The rest of the 49 participants missed two or more weeks of data. Thus, the issue of missing data may decrease the statistical power and bias the results, making it impossible to detect all the significant changes in emotion differentiation in the experiment.

Additionally, there is no control group for this study. We only looked at the changes throughout the therapy within the treatment group. In this study, we want to examine the effectiveness of ACT-DL therapy on improving emotion differentiation compared to TAU, so

without the control group (TAU only), it is impossible to be sure that any change we detected was caused by the ACT-DL+TAU therapy itself and not by other variables. This study did not detect any significant impact of emotion differentiation on social functioning or negative symptoms over the therapy. However, even if it did, we still could not confidently conclude that this change was due to ACT-DL because some other variable might influence it.

Furthermore, the ESM data were completely self-reported, and self-report questionnaires using the Likert scale can sometimes be biased. For example, when participants were unsure how they felt about certain emotions, they might rate the emotions with the most neutral possible answer instead of how they felt. Also, depending on their environment and the time of the day, participants may need more time or cognitive energy to complete all the ratings on the questionnaires carefully. They may get fatigued or exhausted from repeatedly rating the same emotions throughout the day, which can influence the ratings. Besides, due to social desirability, some participants might rate their emotions in a way that makes them look good instead of reflecting their real emotions. Hence, there might be the possibility of invalid and biased answers for the ratings of emotions, making the data flawed.

Last but not least, when measuring the emotions, there were three affects in the positive affect group and four affects in the negative affect group. Hence, the number of measured affects differs in these two affect groups. Also, only having three positive and four negative affect may not be enough to capture participants' ability to differentiate affects in the same affect group. Thus, it can partially explain why we did not detect any significant changes in emotion differentiation in either of the two affect groups over the entire therapy.

4.2. Future directions

Given that no known study has explored the effectiveness of ACT-DL on emotion differentiation and the relationship between emotion differentiation and social functioning and

negative psychotic symptoms, further research is required to replicate and validate the findings in the study. It is necessary to determine whether or not the same results would be found by increasing the sample size to have enough statistical power and using different measures with an increased number of affects to detect the changes in emotion differentiation. The current study found no significant differences in emotion differentiation between time points for positive affects nor any significant impact of emotion differentiation on social functioning and negative symptoms throughout the ACT-DL+TAU therapy. Thus, future research could include the participants from the control group to understand further the effectiveness of ACT-DL in improving negative psychotic symptoms during the intervention period. Moreover, researchers in the future could increase the number of positive and negative affects to induce more variability within each affect group and better detect the changes in participants' ability to differentiate emotions. Also, ACT-DL targets mainly negative affects, so we only detect a significant improvement in emotion differentiation for negative affects. Future interventions should include other therapies that teach people coping strategies for all kinds of affects.

It is also worth noting that there are other ways to calculate ICC in the literature, and researchers can try different ways to get the ICC scores. For the outliers in the study, we ended up analyzing without excluding any of the outliers due to the already minimal sample size. Future studies can use more robust and more advanced statistical methods to deal with the outliers (e.g., outweighing the outliers), so the outliers would not bias the results, and the sample size would not be decreased due to excluding outliers.

Furthermore, future studies should combine ESM with other measures to assess emotion differentiation. As emotion differentiation can be conceptualized and measured differently, a multimethod approach is necessary to capture the broad aspects of emotion differentiation and provide more accurate information. Future research should consider adding cognitive, brain

activity, and behaviour measures on top of ESM to examine different components so emotion differentiation can achieve a more intact picture of early psychosis.

4.3. Summary

To our knowledge, this is the first study to examine the effect of emotion differentiation on social functioning and negative symptom in individuals with early psychosis. We have found statistically significant changes in emotion differentiation over ACT-DL therapy in individuals with early psychosis, but only for negative affect after four weeks of intervention. However, we cannot conclude that the changes in emotion differentiation over the intervention can help reduce negative symptoms or improve social functioning. The results have shown that difficulty in emotion differentiation is indeed a core underlying issue in psychosis, and ACT-DL effectively improves emotion differentiation over time. However, emotion differentiation is not the only underlying issue in this case, and targeting it alone is not enough to help with psychosis. Researchers in the future should also address other underlying issues and combine different types of interventions to achieve a solid improvement in psychosis. These results may be used to inform future research examining emotion differentiation as an underlying mechanism along with other possible factors to understand the onset of psychosis better while advancing the treatment of individuals with UHR and FEP.

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Appendix 1: R script for ICC

```
# Load libraries
library(psych)
library(irr)

# Setting the directory
curdir <- getwd()
setwd(curdir)

# Load data
data_ESM <- read.csv('ESM_df.csv')

# Cleaning the data
data_ESM <- na.omit(data_ESM)

summary(data_ESM)

# Initialize an empty data frame for aggregated data
data_person_ICC <- data.frame()

n.subject <- unique(data_ESM$record_id)

for (i in n.subject) {
  T.subject <- unique(data_ESM$redcap_event_name[which(data_ESM$record_id == i)])

  for (t in T.subject) {
    temp_df <- data.frame(record_id = i, redcap_event_name = t)

    temp_df$ICC_positive <- 1 -
icc(cbind(data_ESM$esm_mood_cheerful[which(data_ESM$record_id == i &
data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_relaxed[which(data_ESM$record_id == i &
data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_satisfied[which(data_ESM$record_id == i
& data_ESM$redcap_event_name == t)]))$value

    temp_df$ICC_negative <- 1 -
icc(cbind(data_ESM$esm_mood_insecure[which(data_ESM$record_id == i &
data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_anxious[which(data_ESM$record_id == i
& data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_irritated[which(data_ESM$record_id == i
& data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_paranoid[which(data_ESM$record_id == i
& data_ESM$redcap_event_name == t)],
                                data_ESM$esm_mood_gloomy[which(data_ESM$record_id == i &
data_ESM$redcap_event_name == t)]))$value

    # Append temp_df to the data_person_ICC data frame
```

```
    data_person_ICC <- rbind(data_person_ICC, temp_df)
  }
}

sum(is.na(data_person_ICC))

summary(data_person_ICC)

boxplot(data_person_ICC$ICC_positive, data_person_ICC$ICC_negative)

# Writing the ICC scores file
write.csv(data_person_ICC, "ICC_table.csv", row.names = FALSE)
```

Appendix 2: R script for Multi-Level Analysis

```
# Load libraries
library(tidyverse)
library(dplyr)
library(ggpubr)
library(rstatix)
library(ggplot2)
library(psych)
library(gplots)
library(lme4)
library(lmerTest)
library(performance)



# Setting the director
curdir <- getwd()
setwd(curdir)

# Read the data for ICC
ICC_df <- read.csv('ICC_df.csv')


# check for missing data
sum(is.na(ICC_df))
ICC_df <- na.omit(ICC_df)

# Data summary
N_pp <- length(unique(ICC_df$participant_id))
N_pp

# Recode week variable
ICC_df <- ICC_df %>%
  mutate(week = recode(week,
                       "act_1_arm_1" = "1",
                       "act_2_arm_1" = "2",
                       "act_3_arm_1" = "3",
                       "act_4_arm_1" = "4",
                       "act_5_arm_1" = "5",
                       "act_6_arm_1" = "6",
                       "act_7_arm_1" = "7"))
week_factor <- factor(ICC_df$week)
class(week_factor)


# Data summary
ICC_negative_summary <- ICC_df %>%
  group_by(week) %>%
  get_summary_stats(ICC_negative, type = "common")
```

```
ICC_positive_summary <- ICC_df %>%
  group_by(week) %>%
  get_summary_stats(ICC_positive, type = "common")


# Remove outliers
quartiles <- quantile(ICC_df$ICC_positive, probs=c(.25, .75), na.rm = F)
IQR <- IQR(ICC_df$ICC_positive)

Lower <- quartiles[1] - 1.5*IQR
Upper <- quartiles[2] + 1.5*IQR

ICC_df <- subset(ICC_df, ICC_df$ICC_positive > Lower & ICC_df$ICC_positive < Upper)

dim(ICC_df)


quartiles <- quantile(ICC_df$ICC_negative, probs=c(.25, .75), na.rm = F)
IQR <- IQR(ICC_df$ICC_negative)

Lower <- quartiles[1] - 1.5*IQR
Upper <- quartiles[2] + 1.5*IQR

ICC_df <- subset(ICC_df, ICC_df$ICC_negative > Lower & ICC_df$ICC_negative < Upper)

dim(ICC_df)

### Fit multi-level models
ICC_positive_model <- lmer(ICC_positive ~ week + (1 | participant_id), data = ICC_df)
ICC_negative_model <- lmer(ICC_negative ~ week + (1 | participant_id), data = ICC_df)

# Print model summaries
summary(ICC_positive_model)
summary(ICC_negative_model)

# Check assumptions
# Normality
check_normality(ICC_positive_model)
check_normality(ICC_negative_model)

# Homoscedasticity
check_homogeneity(ICC_positive_model)
check_homogeneity(ICC_negative_model)


# Data visualization
# Boxplot
ggboxplot(ICC_df, x = "week", y = "ICC_negative",
          color = "darkred", fill = "gray70", add = c("point", "jitter"), width = 0.8,
```

```
        ylab = "Emotion Differentiation (negative)", xlab = "Time Points (week)")

ggboxplot(ICC_df, x = "week", y = "ICC_positive",
        color = "darkblue", fill = "gray70", add = c("point", "jitter"), width = 0.8,
        ylab = "Emotion Differentiation (positive)", xlab = "Time Points (week)")

# Mean plot
plotmeans(ICC_negative ~ week, data=ICC_df, col = "darkmagenta", lwd = 2,
        ylab = "Emotion Differentiation (negative)", xlab = "Time Points (week)")

plotmeans(ICC_positive ~ week, data = ICC_df, col = "darkslategrey", lwd = 2,
        ylab = "Emotion Differentiation (positive)", xlab = "Time Points (week)")

# Visualize model fits
plot(ICC_positive_model)
plot(ICC_negative_model)

# Visualize model residuals
plot(residuals(ICC_positive_model) ~ fitted(ICC_positive_model))
plot(residuals(ICC_negative_model) ~ fitted(ICC_negative_model))

# Model comparison and selection
anova(ICC_positive_model)
anova(ICC_negative_model)
```

Appendix 3: R script for RCI

```
# Load libraries
library(dplyr)
library(JTRCI)

# Read the data
ICC_df <- read.csv('ICC_df.csv')
SOFAS_df <- read.csv('SOFAS_df.csv')
KSNS_df <- read.csv('KSNS_df.csv')

# Remove NAs
ICC_df <- na.omit(ICC_df)
SOFAS_df <- na.omit(SOFAS_df)
KSNS_df <- na.omit(KSNS_df)

# Data summary
N_pp <- length(unique(ICC_df$participant_id))
N_pp

# Recode week variables
ICC_df <- ICC_df %>%
  mutate(week = recode(week,
                       "act_1_arm_1" = "1",
                       "act_7_arm_1" = "2"))

SOFAS_df <- SOFAS_df %>%
  mutate(week = recode(week,
                       "baseline_arm_1" = "1",
                       "post_arm_1" = "2"))

KSNS_df <- KSNS_df %>%
  mutate(week = recode(week,
                       "baseline_arm_1" = "1",
                       "post_arm_1" = "2"))

# Calculate KSNS
KSNS_df$ksns <- rowSums(KSNS_df[, c('ksns_pleasure_intensity', 'ksns_pleasure_freq',
'ksns_pleasure_future',
                                    'ksns_suffer_lack', 'ksns_asocility_behavior',
'ksns_asocility_experience',
                                    'ksns_avolition_behavior', 'ksnsn_avolition_experience',
'ksns_bluntaffect_facial',
                                    'ksns_bluntaffect_vocal', 'ksns_bluntaffect_gesture',
'ksns_alogy_quantity',
                                    'ksns_alogy_elaboration')], na.rm = TRUE)


# Filter data
ICC_pre <- ICC_df %>% filter(week == "1")
```

```
ICC_post <- ICC_df %>% filter(week == "2")
SOFAS_pre <- SOFAS_df %>% filter(week == "1")
SOFAS_post <- SOFAS_df %>% filter(week == "2")
KSNS_pre <- KSNS_df %>% filter(week == "1")
KSNS_post <- KSNS_df %>% filter(week == "2")

# Rename columns
ICC_pre <- ICC_pre %>% rename(ICC_positive_pre = ICC_positive, ICC_negative_pre =
ICC_negative)
ICC_post <- ICC_post %>% rename(ICC_positive_post = ICC_positive, ICC_negative_post
= ICC_negative)
SOFAS_pre <- SOFAS_pre %>% rename(SOFAS_pre = caarms_1c)
SOFAS_post <- SOFAS_post %>% rename(SOFAS_post = caarms_1c)
KSNS_pre <- KSNS_pre %>% rename(KSNS_pre = ksns)
KSNS_post <- KSNS_post %>% rename(KSNS_post = ksns)

# Merge datasets
RCI_df <- ICC_pre %>%
  left_join(ICC_post, by = "participant_id") %>%
  left_join(SOFAS_pre, by = "participant_id") %>%
  left_join(SOFAS_post, by = "participant_id") %>%
  left_join(KSNS_pre, by = "participant_id") %>%
  left_join(KSNS_post, by = "participant_id") %>%
  select(participant_id, ICC_positive_pre, ICC_positive_post, ICC_negative_pre,
ICC_negative_post, KSNS_pre, KSNS_post, SOFAS_pre, SOFAS_post)

# Write RCI data frame
write.csv(RCI_df, "RCI_df.csv", row.names = FALSE)

# Calculate RCI scores
RCI_positive <- JTRCI(data = RCI_df, pre = "ICC_positive_pre", post =
"ICC_positive_post", ppid = "participant_id",
                      reliability = .8, indextype = "RCI", higherIsBetter = T)
RCI_positive <- subset(JTRCIdf, select=c("ppid", "RCI"))
RCI_positive <- RCI_positive %>% rename(PPID = ppid, POS_RCI = RCI)


RCI_negative <- JTRCI(data = RCI_df, pre = "ICC_negative_pre", post =
"ICC_negative_post", ppid = "participant_id",
                      reliability = .8, indextype = "RCI", higherIsBetter = T)
RCI_negative <- subset(JTRCIdf, select=c("ppid", "RCI"))
RCI_negative <- RCI_negative %>% rename(PPID = ppid, NEG_RCI = RCI)


RCI_SOFAS <- JTRCI(data = RCI_df, pre = "SOFAS_pre", post = "SOFAS_post", ppid =
"participant_id",
                   reliability = .8, indextype = "RCI", higherIsBetter = T)
RCI_SOFAS <- subset(JTRCIdf, select=c("ppid", "RCI"))
RCI_SOFAS <- RCI_SOFAS %>% rename(PPID = ppid, SOFAS_RCI = RCI)
```

```
RCI_KSNS <- JTRCI(data = RCI_df, pre = "KSNS_pre", post = "KSNS_post", ppid =
"participant_id",
                  reliability = .8, indextype = "RCI", higherIsBetter = T)
RCI_KSNS <- subset(JTRCIdf, select=c("ppid", "RCI"))
RCI_KSNS <- RCI_KSNS %>% rename(PPID = ppid, KSNS_RCI = RCI)


# Merge data frames into one based on 'participant_id'
RCI_all <- RCI_positive %>%
  left_join(RCI_negative, by = "PPID") %>%
  left_join(RCI_KSNS, by = "PPID") %>%
  left_join(RCI_SOFAS, by = "PPID")

RCI_all <- na.omit(RCI_all)
write.csv(RCI_all, "REG_df.csv", row.names = FALSE)
```

Appendix 4: R script for linear regression

```
library(ggplot2)
library(ggpubr)
library(readxl)
library(psych)
library(car)

# Setting the directory
curdir <- getwd()
setwd(curdir)

# Read the data
REG_df <- read.csv('REG_df.csv')

describe(REG_df)

### Data visualization/exploration
# scatter matrix
pairs.panels(REG_df, hist.col= "firebrick4")

# correlation coefficients
corr.test(REG_df, method="pearson", adjust="bonferroni")

# scatter plots with regression line
# KSNS
plot(REG_df$POS_RCI, REG_df$KSNS_RCI, col = "black", pch=19, cex=0.7,
frame=FALSE,
    xlab = "Emotion Differentiation (positive)", ylab = "Psychotic Symptoms")
abline(lm(KSNS_RCI~POS_RCI, data=REG_df),col='red', lwd = 2)
coef <- round(coef(lm(KSNS_RCI~POS_RCI, data=REG_df)), 2)
text(-1.5, 1,  paste("Y = ", coef[1], "+", coef[2], "x"))


plot(REG_df$NEG_RCI, REG_df$KSNS_RCI, col = "black", pch=19, cex=0.7,
frame=FALSE,
    xlab = "Emotion Differentiation (negative)", ylab = "Psychotic Symptoms")
abline(lm(KSNS_RCI~NEG_RCI, data=REG_df),col='red', lwd = 2)
coef <- round(coef(lm(KSNS_RCI~NEG_RCI, data=REG_df)), 2)
text(-1, 1,  paste("Y = ", coef[1], "+", coef[2], "x"))


# SOFAS
plot(REG_df$POS_RCI, REG_df$SOFAS_RCI, col = "black", pch=19, cex=0.7,
frame=FALSE,
    xlab = "Emotion Differentiation (positive)", ylab = "Social Functioning")
abline(lm(SOFAS_RCI~POS_RCI, data=REG_df),col='red', lwd = 2)
coef <- round(coef(lm(SOFAS_RCI~POS_RCI, data=REG_df)), 2)
text(-2, 5,  paste("Y = ", coef[1], "+", coef[2], "x"))
```

```
plot(REG_df$NEG_RCI, REG_df$SOFAS_RCI, col = "black", pch=19, cex=0.7,
frame=FALSE,
    xlab = "Emotion Differentiation (negative)", ylab = "Social Functioning")
abline(lm(SOFAS_RCI~NEG_RCI, data=REG_df),col='red', lwd = 2)
coef <- round(coef(lm(SOFAS_RCI~NEG_RCI, data=REG_df)), 2)
text(-1, 4.5,  paste("Y = ", coef[1], "+", coef[2], "x"))



### Regression analysis
# KSNS model
KSNS_model <- lm(KSNS_RCI~POS_RCI + NEG_RCI, data=REG_df)
summary(KSNS_model)

confint(KSNS_model, level=.95)
vif(KSNS_model)
plot(KSNS_model)
residualPlot(KSNS_model, fitted=TRUE, type="rstudent", test=TRUE)


# SOFAS model
SOFAS_model <- lm(SOFAS_RCI~POS_RCI + NEG_RCI, data=REG_df)
summary(SOFAS_model)

confint(SOFAS_model, level=.95)
vif(SOFAS_model)
plot(SOFAS_model)
residualPlot(SOFAS_model, fitted=TRUE, type="rstudent", test=TRUE)


# Simple linear regression
KSNS_POS_model <- lm(KSNS_RCI~POS_RCI, data=REG_df)
summary(KSNS_POS_model)
confint(KSNS_POS_model, level=.95)
plot(KSNS_POS_model)

KSNS_NEG_model <- lm(KSNS_RCI~NEG_RCI, data=REG_df)
summary(KSNS_NEG_model)
confint(KSNS_NEG_model, level=.95)
plot(KSNS_NEG_model)

SOFAS_POS_model <- lm(SOFAS_RCI~POS_RCI, data=REG_df)
summary(SOFAS_POS_model)
confint(SOFAS_POS_model, level=.95)
plot(SOFAS_POS_model)

SOFAS_NEG_model <- lm(SOFAS_RCI~NEG_RCI, data=REG_df)
summary(SOFAS_NEG_model)
```

```
confint(SOFAS_NEG_model, level=.95)
plot(SOFAS_NEG_model)
```