



Master's thesis

Exploring Identity Dynamics and its Impact using Non-Linear Techniques

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Are there deviations of the Master's thesis from the proposed plan?

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Yes, please explain below the deviations

Abstract

Identity has been extensively studied and its fluctuating uncertain development in response to our experiences has been pointed out. Nonetheless, proper nonlinear complexity analysis of identity and its impact is missing. In this proof of concept study, the non-linear dynamics of identity variables and a well-established related variable, well-being, are being examined. This study included a three-month daily data collection phase, but only one participant's time series was analyzed in the end. The time series of the variables were analyzed using Cross-Recurrence-Quantification Analysis to look for signs of deterministic coupling and unpredictability. The data supports non-linear coupling between identity variables and well-being but fails to find decisive evidence for unpredictability. While the generalisability of the results is questionable, novel techniques are applied and results are congruent with contemporary identity research. The appropriateness of the technique and further research are discussed.

Exploring Identity Dynamics and its Impact using Non-Linear Techniques

Identity is often defined as a “sense of self”, that gives us the feeling that we are the same person, despite going through significant changes throughout our life, and that this identity can be communicated with others (Branje et al., 2021). It has been shown, that a well-developed identity, especially during adolescence, is vital to our self-understanding and well-being (Meeus, 2011). However not much is known about the dynamics and exactly how identity and well-being interact. This proof of concept study attempts to explore the applicability of a nonlinear complex dynamic system approach to identity and well-being. Our framework of identity dynamics influences not only our definition and research on identity but also has implications for mental health services, for example through the use of identity interventions for individuals to gain a more positive self-image (Archer, 2008). As identity has been associated with well-being in the literature, it is vital to get a proper understanding of how the dynamics of the two variables couple together.

Research on Identity

Identity has been extensively studied in psychology and social sciences since the work by the psychoanalyst Erikson in the 1950s and 1960s. In Erikson's (1956) early conceptualisations, identity was described quite vaguely, as a phenomenological experience that gives us a sense of sameness despite going through significant changes and feeling unique, which are both integrated with our history, biology, and environment. According to Erikson, there are multiple identity domains in which our identity develops, namely “Occupation” and “Ideology”, though more domains have been added over the years. Already in Erikson's early work, he proposed that developing a sense of who we are is associated with increased happiness and well-being, and over time, many theories and concepts around identity have emerged. Marcia (1966) established one popular approach in psychological research to assess and

compare identity states and dynamics quantitatively with each other, as well as other variables like well-being. The term identity commitment was introduced and refers to an idea we develop about ourselves within an identity domain. They are called commitment due to the implications they have for our behaviour. For example, identifying with one's occupation likely is going to result in more engagement and focus on it. By using questionnaires or identity interviews (Bosma, 1985), identity and its “state” can be compared with other individuals or variables by estimating the degree of commitment strength (identity “commitment strength”) and the degree of past identity exploration. Commitment strength describes how certain we are that a commitment within an identity domain fits ourselves and thereby how likely and willing we are to change it. The second variable is identity exploration, which describes the degree to which we were engaged with activities or thoughts of testing out different identity commitments and also how much we have explored a particular commitment. This approach to assessing and comparing identity has become quite popular (Meeus, 2011), as it allows researchers to quantify, relate and compare identity states between individuals and analyse them in relation to well-being.

Depending on the combination of identity commitment strength and identity exploration, four different identity statuses have been proposed (Marcia, 1966). Not exploring any commitments and also not being committed to any has been coined *diffused*; engaging in exploration but not having developed any high levels of commitment strength is called *moratorium*; *foreclosed* refers to high commitments in certain domains but low levels of exploration; lastly *achieved* refers to strong commitments while having explored a lot or still exploring new identities. As might be expected, *achieved* is the “ideal” final identity state in which we explored a lot of identity commitments and have integrated our experiences into a stable sense of who we are. This state is most associated with increased well-being (Waterman, 2007) as we finally would have fostered a secure sense of who we are, which gives us direction

and guidance. Over the decades, researchers had to acknowledge that relapse into previous states is possible and consequently the final state does not imply an unchanging final state (Klimstra et al., 2010; Kroger et al., 2010). Also, while an initial order in which individuals go through identity stages was suggested, frequent variations of it make the validity of a single linear development towards identity *achieved* questionable. Additionally, in early research, identity has been assumed to be rather stable and slowly changing, but recent studies support the more dynamic notion of identity (Branje, et al. 2021), and that it has the potential to change within a week or even daily (Klimstra et al., 2010; van der Gaag et al., 2016). While identity is formed through our experiences, neither negative nor positive experiences exclusively predict whether an identity commitment strength will increase or decrease (Kerpelman et al., 1997; van der Gaag et al., 2017). On top of these limitations, considering the wide variety of factors that have the potential to influence our daily well-being (Eger III & Maridal, 2015), researching identity variables dynamics and their relation to well-being from a linear causality perspective (I.e. change in x implies a change in y) is rather questionable. Instead, identity might behave like a fluctuating system whose dynamics are hard to predict.

Identity Dynamics as a Complex Dynamic System

One framework to approach and research identity's relationship with well-being, with the assumption that it is a nonlinear dynamic process, is a complex dynamic system approach. In complex dynamic system theory, variables are not considered static but rather unstable variations around an attractor state, and transitions between attractor states may occur (Kunnen & van Geert, 2012). Due to the ever-changing nature of variables in a complex dynamic system and their interconnectedness, an increase in x may result in unpredictable changes in y. Rather than assuming linear relationships, variables are considered to be interacting non-linearly with possibly an uncountable number of other variables within the system. In the case of identity and well-being, experiences that enhance our commitment strength may be associated with increased

feelings of well-being at some points, but also may be associated with negative feelings. For example, achieving a desired goal, or failure to achieve that goal may both have the potential to strengthen or weaken our commitments. Attributing linear change and variance due to specific variables is rather uncommon in this framework.

One model that attempts to combine the identity status approach and concepts from a complex dynamical system perspective is the *landscape model of identity* (Van der Gaag et al., 2020). The model extended the status model of identity by describing identity as a constellation of commitments, with possible overlap between commitments. The model also exchanged identity exploration with identity integration as a necessary variable to categorise identity into one of the four identity statuses (*achieved, diffused, etc.*). Identity integration refers to the similarity of content in different identity domains, how broadly an identity applies, and to what extent it helps us navigate our behaviour. Consequently, a highly integrated identity is more invasive when engaging with our environment compared to low levels of integration. Just like exploration did before, levels of identity integration and commitment strength describe now the current state of identity. A common metaphor in complex dynamic systems, which the landscape model uses as well, is that of valleys to help visualise the behaviour of identity dynamics (Richardson et al., 2014). Identity may be viewed as a landscape of commitment valleys in which the depth and width of the valley describe the commitment strength and integration respectively. A ball is used to help us imagine our trajectory through the valleys. As we go through our life, deep valleys are hard to escape and less likely to change, and our experience is more likely to “roll” into wide valleys. A deep and wide valley would be considered an attractor as we are more likely to roll into the valley which is harder to escape. At the same time, the shape of the landscape changes in response to our experiences. The trajectory or development of identity variables is more relevant in explaining their current relevance to our well-being than the current static position in the landscape. Integrating identity commitments does not only

describe the pervasiveness of particular commitments in day-to-day life but may also result in overarching identity commitments with an extensive application in our daily life, overlapping many identity commitments. For example, out of initial identity commitments like “I am a father figure to my kids”, “I am a firefighter”, and “I am helping at a homeless shelter” may result in the overarching idea of oneself “I really want to help people”.

An identity model which anticipates a continuous change of our identity while also incorporating the possibility of forming stable attractor states sounds more appropriate to explain and describe what is actually happening in identity dynamics than the static identity status approach. However, exploring a more complex model of identity dynamics will require the usage of advanced non-linear techniques on longer extensive time series. Which poses some methodological challenges. While already many authors acknowledged the unstable changing nature of identity and categorised it as complex (Branje et al., 2021), to the author's knowledge nonlinear complexity measures are not being used to test this empirically. This paper aims to address the current gap in the literature by exploring a complex dynamic framework and applying a non-linear analysis of identity dynamics. This will be an explorative study to test for nonlinear coupling among identity variables of the identity status approach and the landscape model of identity (commitment strength, commitment exploration, and commitment integration) with well-being, a well-established related variable to identity within the identity literature (Meuss, 2011). The aim is to gain insight into the usefulness of the nonlinear approach to identity and to demonstrate the usefulness of the technique applied.

The Current Study

In order to explore the applicability of a non-linear framework on identity dynamics and well-being, an explorative “diary” study was designed. Over the course of three months, we assessed the participants' daily well-being, their perceived commitment strength toward their identity, their degree of identity exploration, in-depth and alternative identity exploration, and

the degree to which identity felt utilised (integrated) into daily activities. To look for signs of non-linear coupling between identity variables and well-being, we applied a Cross-Recurrence Quantification Analysis (CRQA). This particular analysis does not have many assumptions and is designed to quantify recurrence patterns in multidimensional phase space by creating copies of an original time series at a certain lag (Wallot & Leonardi, 2018). By analysing the trajectories, the analysis is able to pick up whether phase space trajectories of one or multiple variables are following deterministic patterns and also distinguishes the degree to which the variables within the system of interest can be reliably predicted from each other or not (Webber & Zbilut, 2005). A system thereby has the potential to be minimally predictive or highly predictive despite being more or less deterministically coupled. Based on the presented research, we hypothesize, that well-being and identity variables should couple, but assuming that identity is behaving like a complex system, this coupling is rather short-lived and unpredictable. To the best of our knowledge, there has been yet no attempt to combine identity and well-being measures with techniques like CRQA to understand and examine their dynamics for indicators of non-linear coupling. A part of the discussion and result will therefore also address the process and interpretation of performing a CRQA in a study like this.

Methods

For this explorative “diary”, a long identity interview was conducted in the beginning, to get a detailed reflection of participants on their identity domains. Their most central identity domain will be used in the diary study. They will reflect upon it daily as well as their state of well-being. Due to its exploratory nature, a time frame of three months was deemed appropriate in which participants could record their data. In the end, additional questions about the possible impacts, consequences, and implementation of the study were asked.

Measurements

Identity Interview and the GIDS.

Exploring the daily dynamics of identity, the commitment, its integration, and possible nonlinear coupling with perceived well-being required measurement tools that can be used regularly without boring participants, taking up too much of their time but simultaneously capturing the uniqueness of the participants' identity. The Groninger Identity Development Scale (GIDS), currently in its fourth revision (Van der Gaag et al., 2022), is a semi-structured interview with qualitative and quantitative assessments. Across 2-4 hours participants are interviewed on different identity domains within their life. The domains are “Occupation”, “Family”, “Leisure Time”, “Friendships”, “Intimate Relationships” and a “Flexible Domain”, in the latter participants can discuss aspects that might not have been captured in the other domains. The last domain is an “Overarching Domain” in which participants reflect on common themes or central aspects of their identity which may summarise multiple specific domains. However, not every interviewee is expected to have developed an extensive identity across all domains or be able to identify an overarching commitment. The GIDS proposes multiple open-ended questions for each domain but intends to guide a free-flowing conversation between researchers and participants. At the end of each domain, participants formulate a statement about who they are with respect to the currently discussed domain and what it means to them; their domain-specific commitment. In conclusion of each domain and their statement, they answer a short questionnaire that aims to quantify commitment strength, integration, and exploration for each domain statement. This serves to establish consensus between researcher and participant about the degree of commitment strength or integration and to allow comparisons between individuals, even though the content of domain-specific commitments is unique for each individual. For this study, the “Overarching” identity statement was used for the daily assessment since it is by participants' own definition the most central and comprehensive to their identity.

Daily Identity Assessment

As part of the daily identity assessment the participants were shown the central identity statement daily, followed by adapted questions from the GIDS questionnaire. At first, participants would read their statement and indicate whether it had changed and made appropriate changes in case it did. The either original or adapted statement was then reflected upon with six statements each addressing either commitment strength, integration, or exploration. The statements were “Please indicate whether today you felt certain about the commitment”(Commitment strength), “Please indicate whether today you’ve been exploring alternatives to your commitment”(Exploring alternatives), “Please indicate whether today your actions were guided by your commitment?” (Commitment integration), “Please indicate whether today you actively tried to further develop this commitment?” (Exploring in-depth), “Please indicate whether today you were influenced by your commitment?” (Commitment integration) and “Please indicate whether today your commitment felt fitting?” (Commitment strength). Each question was answered on a visual analogue scale (a slider), ranging from 0-100, with the indicators “Not at all”, “Moderately” and “Very much”. Participants were unaware of the exact value that they entered at each assessment.

Well-Being Questionnaire

In order to assess well-being regularly, we’ve chosen to pick items from the ‘Hownutsarethedutch’ (“HoeGekIsNL”) study which assessed well-being, quality of life items and depressive symptoms multiple times a day (Van der Krieke et al., 2016). Seven items were picked and adapted to refer to the current day. All of them were answered on a 0-100 slider, unaware of the exact value. The first question was “How are you doing today”, and rated from 0=Very bad, 50=Neither good or bad, to 100=Very good. The following questions were rated from 0=Not at all, 50=Moderately, and 100=Very much. They included: “During today’s activities, did you feel unbalanced?”, “During today’s activities, did you feel relaxed?”, “During today’s activities, did you feel irritable?”, “During today’s activities, did you feel gloomy?”,

“During today’s activities, did you feel content?” and “During today’s activities, did you feel energetic?”. The first item is a general quality of life item, designed for daily usage, while the 6 follow-up questions are from an affect/ mood questionnaire since we expected these items to be more based on the current day, and show increased variability.

Study Evaluation

Due to the explorative nature of the study, at the end of the study the aim was to also include participants' feedback about the study's accessibility, implementation, and possible negative effects that it might have had on them. We first asked them an open question, “How did you experience the diary study? Has it affected you, and if so, how?”. The next multiple choice question addressed possible negative effects by asking “Would you say that your participation impacted your well-being?” with the choices being “Yes, positively”, “Yes, negatively”, “Not really” and “Not at all”. If participants report a negative experience, a post-study interview with the researchers is offered. The next questions about the implementation of the study were answered on a 0-100 scale (0=Not at all, 50= Moderately, 100=Very much) and included the questions “How difficult did you find it to reflect on your identity commitment on a daily basis?”, “How difficult was it to access the study?”, “Was the content of the question and process clear to you?” and “How difficult was it for you to participate on a regular basis?”. At last, participants were allowed to leave a final comment or remark.

Process and Recruitment

It was estimated that a 2-4 hours identity interview followed by 3 months of daily assessment, which were expected to take up one and a half minutes every time on average, meant that participants would have to sign up for an expected 4-6 hours of study participation stretched out over 3 months. Due to the challenges and the explorative background of this diary study, a convenient sample was deemed acceptable. A separate ongoing study on the GIDS was used to conduct the interview and recruit participants from it for the daily assessment.

Participants were Bachelor of Psychology students from the University of Groningen who were taking part in exchange for partial course credits and were offered a generous amount in exchange for their participation. The interviews took place in person on the campus of the University of Groningen and the daily assessments were conducted online, allowing participants to access it through the SONA portal or an email distribution system. Each assessment started with the well-being questionnaire followed by the identity assessment. On the last day of the study, the evaluation questions were added. Participants were instructed that they may miss five non-consecutive days to continue participating.

Time restrictions allowed only five participants to sign up for the diary study to complete their intake and first assessment. Only three participants entered their data for more than one day and only one participant participated for 2 whole months. Only the last participant provided a complete enough dataset, and this participant will be used to conduct the CRQA analysis and reflect on the applicability of this technique and a nonlinear framework in identity research. The participant was male and 19 years old.

Cross-Recurrence-Quantification Analysis

CRQA is most often done on thousands of time points but even short time series have the potential to yield interesting results (Chih-hao et al., 2008) since the analysis makes no assumption about the number of time points or behaviour of the system (linear vs non-linear). As mentioned the analysis quantifies recurrences of the time series in multidimensional phase space and three parameters will be set as part of the analysis, the *delay* at which lag copies of the original time series are created; *dimensions* or how many copies are created and *radius* which describes at what distance, points are considered recurrent (Giasemidis & Greetham, 2018). The analysis will result in several scores. *%REC* (recurrence rate): this is the first and most basic outcome, as it indicates the percentage from all points in the time series that are considered recurrent in the phase space. *%DET* (determinism): denotes the percentage of recurrence points

that form successive line structures. Diagonal line structures imply that the dynamics of the two lagged variables are following the same trajectories. The higher determinism, the more casually intertwined and deterministic the variables within the system are. The last variables which describe deterministic behaviour in the system are *NRLine* (number of lines), *Max Line* (length of the longest diagonal line), and *Mean Line* (the mean length of diagonal lines). High scores in these are indicators of high deterministic behaviour in the system of interest. CRQA also gives us an estimation of how many data points are spent in the same state (*Laminarity*: percentage of repeating time points, *Trapping Time*: average duration within the same state). The last outcome of the analysis is called *entropy* which calculates the probability distribution of diagonal lines. A system, in which diagonal lines are all of the same lengths, will have a value of 0 for *entropy*, while a more chaotic system, like the commonly exemplified Hénon attractor, results in a 2.557 (Webber & Zbilut, 2005). For the current study it and our hypothesis it implies that identity variables and well-being should be deterministically intertwined but also have high values of entropy, implying that predicting reliably the behavior of one variable through the other variable is not possible.

Results

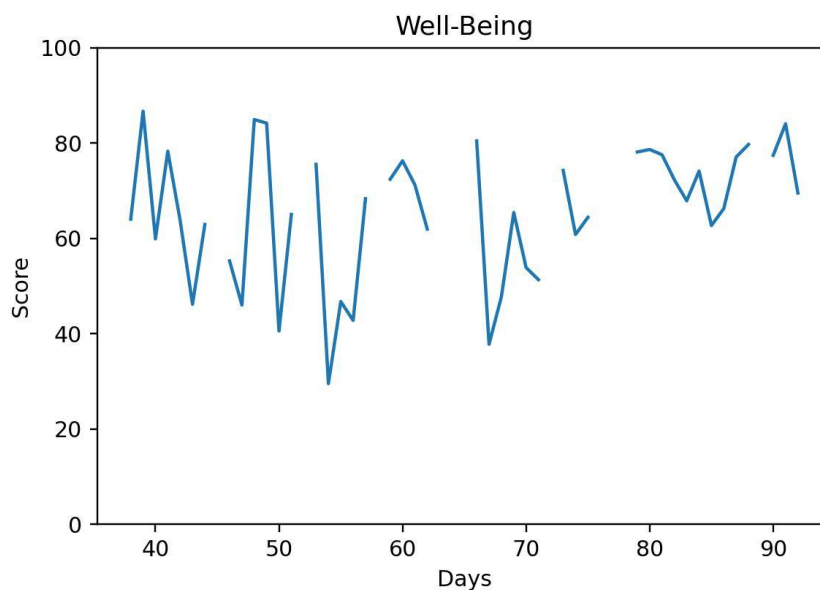
First, the items of the questionnaires will be analysed for their reliability, transformed, and summarized. Missing data will be interpolated and then the parameters for the Cross-Recurrence-Quantification Analysis are set. Next, the results of the CRQA and at last, the practical implementation of an identity diary study like this one will be discussed, using the participant's reflection on the study. In total the participant participated only on 45 days, out of the originally 93 total days planned, but all of them were within 55 days, resulting in 10 missing days of data in between. The participant took on average $m = 74.89$ ($sd = 55.82$) seconds to complete each assessment.

Item Analysis and Missing Data

At first we analysed the items for internal consistency. After reverse scoring the necessary items, Cronbach's alpha for the six well-being items lies at $\alpha = .734$ (95%CI = .608; .828), indicating that the items should have adequate internal consistency. On top of that, we can see in Figure 1, that the participant took part in the study on particular good but also bad days. This gives more credit to the results since it implies that participation on a given day was not biased by well-being.

Figure 1

Time Series of Well-Being

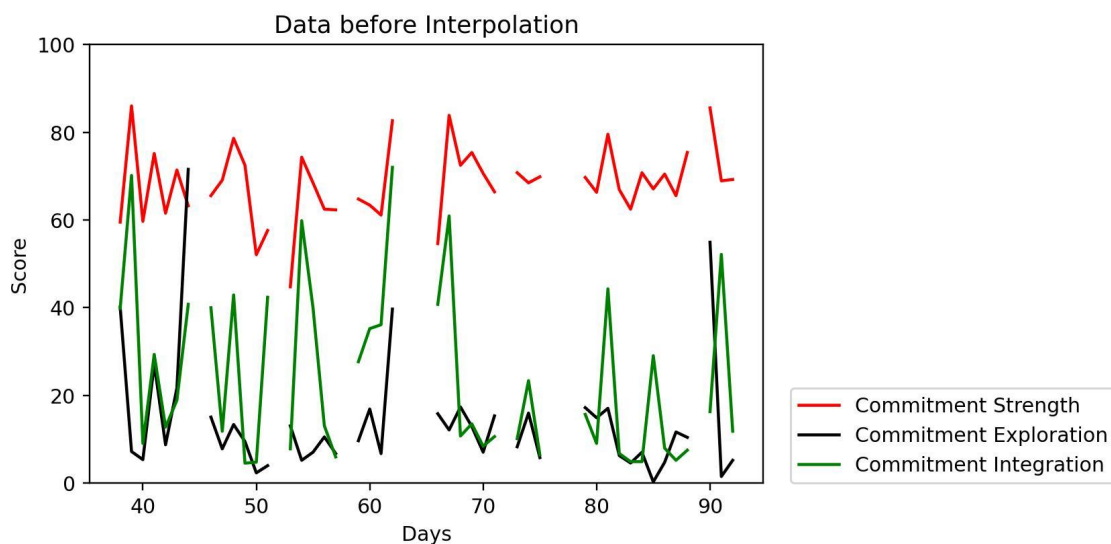


For the identity items, a simple correlation was done to assess the internal validity of the items. Interestingly, the strength items of the participant had the lowest correlation with $r = .239$. This is surprising, because the items were not meant to split into sub-concepts. Identity exploration, which was separated into in-depth exploration and alternative exploration, had the highest correlation of $r = .459$. Identity integration items, correlated with $r = .389$. While the low

correlations are limitations for further interpretation, they also offer an in-depth look into individuals' perceptions of their identity and showcase, that validity of standard questionnaires is rather difficult to interpret, especially on the individual level for a nuanced concept like identity. After averaging the two items for each identity variable, the resulting time series are visualised in Figure 2.

Figure 2

Time Series of Identity Items

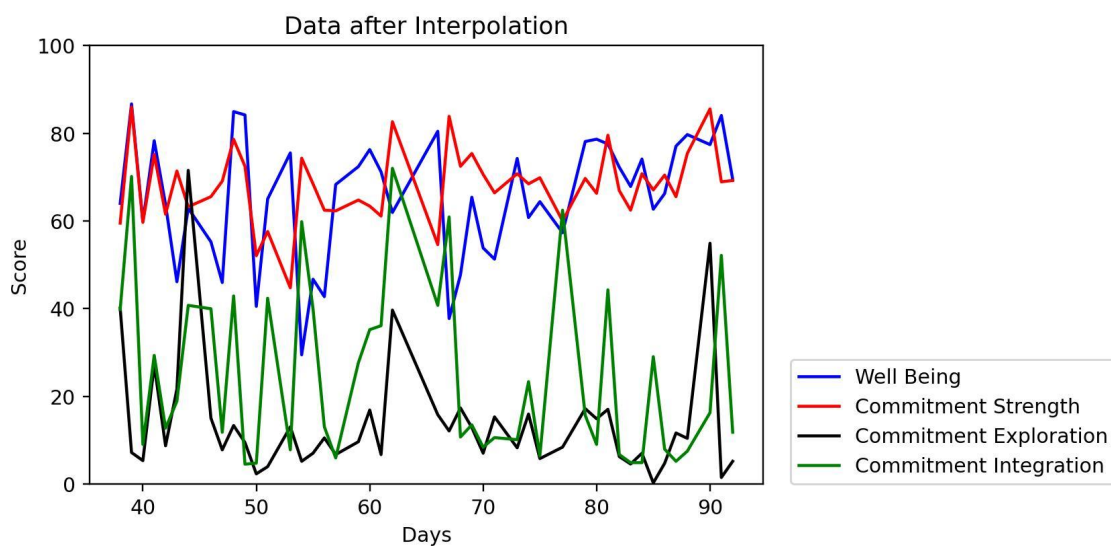


While CRQA and its variation are rather robust, interpolating missing values for analysis poses the threat of influencing the results, therefore reducing the maximum number of consecutive missing entries was key for reliable results in our analysis. In this study, a maximum of 3 consecutive missing days was recorded. It should be noted, that doing the analysis without imputation of missing days results in some lower values for %DET (percentage diagonal line), but it was decided to preserve the relative position of each timepoint to not reshape the dynamics as reported by the participant. For this study, linear interpolation data was chosen,

based on previous work for handling missing data for Recurrence-Quantification Analysis and its variations (Brick et. al., 2018). The resulting time series after interpolating the data can be seen in Figure 3.

Figure 3

Time Series After Linear Interpolation



Parameters

For recurrence quantification analysis and its various variations, common methods for the choice of the number of *dimensions* and the number for the *delay* include the first minimum of false nearest neighbourhood method (*dimension*), and the first minimum in a mutual information plot, or autocorrelation plot (*delay*), while for the *radius* parameter, machine learning algorithms or the 1% recurrence rate are often used (Giasemidis & Greetham, 2018). With every increase in *delay* and *dimension*, the time series analysed shortens down. This is usually nothing to worry about in a time series with at least 1000 time points. Since the time series for this diary study lies at 55-time points, this may result in some problems. In order to

counteract the potential problem, the data was made categorical so choosing a radius gets easier ($radius = 0$, any difference is considered categorically a difference). To create categories of our data, the difference scores between all time points and their successive time points were calculated, creating another time series with the rate of change as new values in the process. Each difference was then categorised as either a *big decrease* (at least -15), *big increase* (at least +15), *small decrease*, or *small increase* (decrease of -5 but not more than -15, increase of at least by 5 but no more than 15) and *no change* if the difference was between -5 and +5. Using the rate of change instead of ranges of values (for example from 1-25) prevents accidentally categorizing changes between value ranges which actually might have been only minor changes. Next, we used an autocorrelation plot to choose the *delay* and the false nearest neighbours method for the *dimensions* by identifying the first local minimum and picking one that fits all (Giasemidis & Greetham, 2018). Results recommended using either a 1 or 2 for the *delay* as well as for the number of *dimensions*. Pre-testing the analysis showed when the number of *dimensions* is equal to 1, changing the *delay* between 1 or 2 does not influence the results. Due to the already explorative nature of the study, two sets of parameters were used. The first set uses $delay = 1$ and $dimension = 1$ and the second set uses a $delay = 2$ and $dimension = 2$ to compare the impact of parameters choice on a short time series like ours.

Categorical Cross-Recurrence-Quantification Analysis

In Table 1, the results for the CRQA between well-being and the identity variables (commitment strength, commitment exploration, commitment integration) are summarised. When changing the number of dimensions, certain results change quite drastically (number of recurrence points, percentage of diagonal lines, number of diagonal lines, and the percentage of vertical line structures).

Table 1

CRQA Results for Identity Variables and Well-Being

Variable	Dimensions	%Rec	%Det	Nr Line	Max Line	Mean Line	Laminarity	TT	Entropy
Strength	1	51.61	73.69	361	12	3.07	87.4	4.57	1.41
	2	27.03	40.36	95	10	3.11	62.11	4.49	1.36
Exploration	1	52.5	73.48	375	11	3	87.92	4.17	1.38
	2	26.81	39.31	89	9	3.2	56.14	4.63	1.48
Integration	1	46.88	69.93	337	13	2.84	77.39	3.56	1.23
	2	21.23	29.44	60	11	2.82	37.46	2.83	1.18

Note. Outcome variables include %Rec= percentage of recurrence points; %Det = percentage of recurrence points that form a diagonal line; NrLine = number of diagonal lines; Max Line = length of the longest line; Mean Line = mean length of diagonal lines; Laminarity = percentage of points forming vertical lines; TT (Trapping Time) = average length of vertical lines; Entropy = Shannon information entropy of diagonal lines.

The results of *%REC*, *%DET*, *NRLine*, and *Laminarity* are quite affected by the choice of parameters, the other outcome variables on determinism (*Max Line*, and *Mean Line*) result in considerably small changes. The latter supports the robustness of CRQA, despite working with limited data. The *Max Line* ranges around 9-13, implying that the longest time for this person that changes in identity variables are coupled with changes in well-being, is 9 to 13 days. The *Mean line* indicates that ~3 days on average do identity dynamics and well-being show shared trajectories. While differences between identity variables are rather neglectable, a first minor difference is found for the *Mean Line* which will extend into the follow-up outcome variables. The *Mean Line* outcome indicates that identity integration seems to be slightly less coupled to

well-being than other identity variables. *Trapping Time* shows the average time variables are “stuck” together in the same state and range between 2.83 - 4.57, again identity integration has the lowest *TT* values. This increases the suspicion from previous outcome variables, that identity integration for the participant is not as relevant for their well-being on a daily basis relative to the other identity variables. Comparatively identity integration couples for the shortest period with well-being. All the identity variables result in rather high rates for *%DET*, while other indicators of deterministic coupling indicate a rather short window of shared trajectories. The outcomes further seem to support the notion of coupled behaviour between identity variables and well-being, but that this coupling is rather short-lived on a day-to-day basis.

Entropy does confirm a degree of complexity in the coupling (1.18 - 1.48), but far from the unpredictability examples from complexity sciences (for example the Hénon equations *entropy* = 2.0, and Lorenz attractor *entropy* = ~5) (Pellecchia & Shockley, 2005). Based on the *entropy* results, there is no support for high levels of complexity and unpredictability in the coupled dynamics between well-being and identity variables. As part of the Cross-Recurrence-Quantification analysis, a 2-dimensional representation of the recurrence patterns can be seen in Figure 4. It should be noted that the set of parameters with the higher values results in fewer line structures but certain structures are captured independent of the choice of parameters.

Study Evaluation

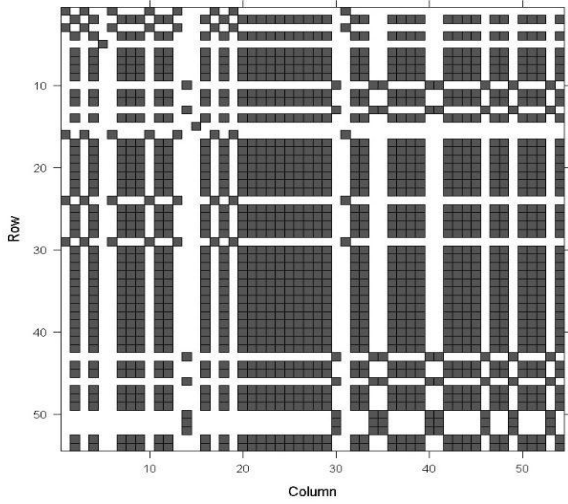
The student indicated that the study made him more aware of his commitment and strongly disagreed that participation influenced his perceived well-being. The results of the study evaluation can be found in table 2. While the implementation of the study seems to be sufficiently planned and accessible, the participant, unfortunately, didn't let us know why he participated for only 2 months. No further comments were left. Future studies which attempt to replicate a setup like this need to consider the accessibility, clear communication of how the

participants can access the study, necessary rate of participation, and possibly consider rewards for monthly or two monthly participations. While recruitment of participations and for participants to integrate daily assessments seems difficult, maintaining participation might be not too difficult due to the short time it took the participant every day and the feedback given by the participant.

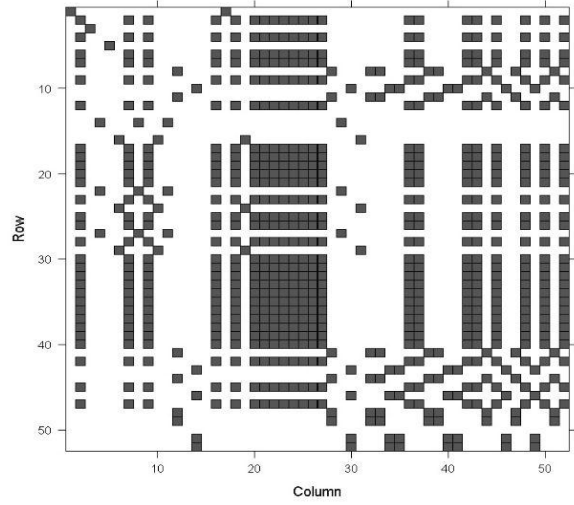
Figure 4

Cross-Recurrence Plots between Well-Being and Identity Variables

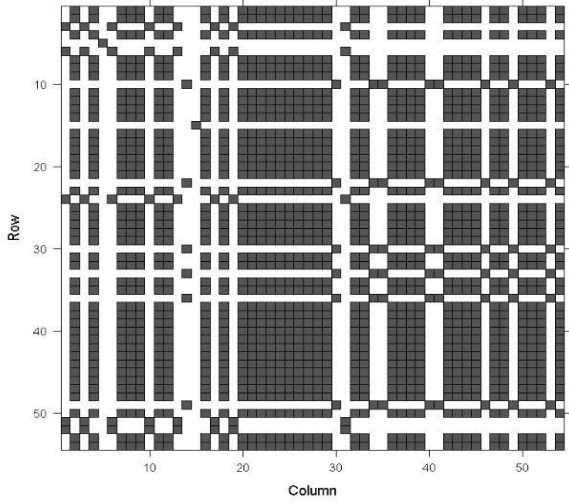
Commitment Strength; Delay & Dimension set to 1



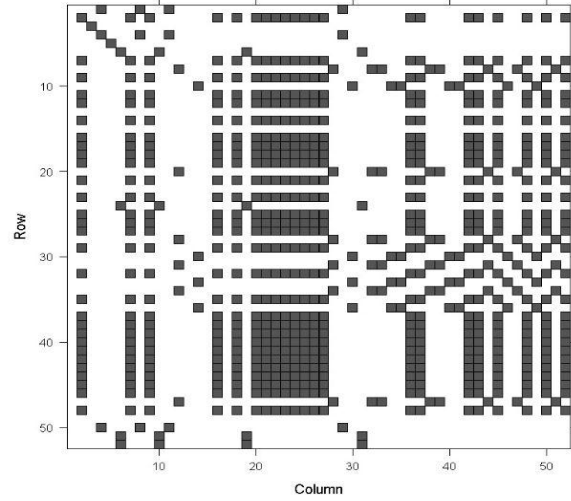
Commitment Strength; Delay & Dimension set to 2



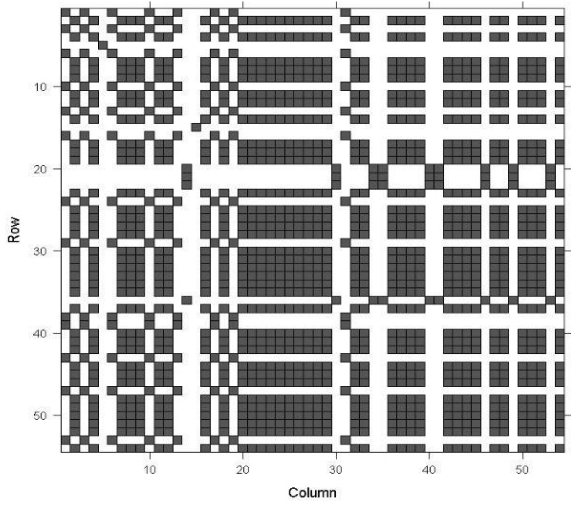
Commitment Exploration; Delay & Dimension set to 1



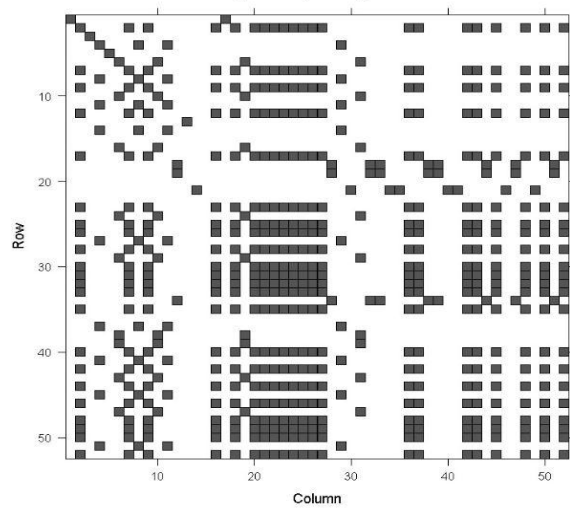
Commitment Exploration; Delay & Dimension set to 2



Commitment Integration; Delay & Dimension set to 2



Commitment Integration; Delay & Dimension set to 2



Note. In the first column are the resulting recurrence plots if the embedding dimension is set to 1, and the second column shows recurrence plots for the number of dimensions set to 2. The row and column values refer to which time points are analyzed for recurrence in the plot.

Table 2

Study Evaluation by Participant

Question	Score
“How difficult did you find it to reflect on your identity commitment on a daily basis?”	25
“How difficult was it to access the study?”	6
“Was the content of the questions and process clear to you?”	92
“How difficult was it to participate on a regular basis?”	34

Discussion

To answer the first part of our research question, identity variables and well-being show deterministic coupled trajectories and relative to the other identity variables identity commitment integration has the lowest outcomes of deterministic coupling. The results are in line with previous research, which related identity with well-being (Meuss, 2011) but allows us to have a more detailed examination. To get the *delay* parameter autocorrelation was used, which in itself indicates time dependency (1 or 2 days), assuming a linear relationship. CRQA as a follow-up analysis, which is sensitive to non-linear behaviour, indicated a slightly longer time frame of deterministic coupling for an average of 3 days. The results, therefore, provide further indication of non-linear behaviour within the system, since methods that take non-linearity into

account, suggest longer coupled relationships. Regarding the second part of our research questions, the complexity of the coupling behaviour is more difficult to interpret. *Entropy* values are neither high nor particularly low. High *entropy* levels were hypothesised, though they are not approaching 0 either. As seen in the results, identity variables or well-being are not coupled beyond a rounded-up average of 4 days and were “stuck” together for a maximum rounded-up average of 5 days. Therefore, the results suggest a moderate degree of predictability between identity variables and well-being.

The results fit partially into recent identity literature as quoted above. As already mentioned the results are congruent with the proposed coupling between identity and well-being and support the notion that identity is behaving non-linearly but fails to make a decisive case for complex interaction and its unpredictability. Instead, there seem to be small windows of shared coupled development. Taking into account Figures 1 to 3, in which some spikes in identity variables coincide with spikes of well-being, one conclusion may be that in response to certain identity-related experiences, identity variables may couple with well-being non-linearly for a few days before “loosening” this coupling. This is perhaps less unpredictable than initially proposed since one would only have to identify key identity-related moments and could then make predictions for the short-term development or at least expect that its development might couple with well-being. For identity research, the results imply, that when studying identity development quantitatively in response to identity-related moments, the changes should be analysed using non-linearity in mind. Though, due to some limitations and indefinite results regarding the complexity of the coupling, describing their relationship as such seems inappropriate. While the results suffer from limitations, the author nonetheless argues for the usage of the CRQA technique, since the technique is quite robust, and offers a within-individual analysis of the nuanced experience “identity”. Instead of describing identity as a current state,

the dynamics around it give a better indication of whether and how well-being and identity currently influence each other.

As a first limitation, it should be remembered, that the internal consistency of the identity items was not ideal and finding appropriate quantitative measures for a nuanced concept like identity will likely remain a challenge. The main limitations are that comparison data is missing and the timeframe of 55 days could be considered a short time frame when considering that identity is changing even in later years. Having just one participant makes generalisations about dynamic variables for the whole population hard, especially regarding the research question of predictability and complexity. To potentially add validity to the results for individuals, future studies could consider a post-study interview, which incorporates conclusions drawn from the analysis into the interview and compares them with individuals' subjective experiences. Nonetheless, CQRA results seem promising and should yield reliable results, as long as the behaviour of the system has been adequately captured (Wallot & Leonardi, 2018). Potentially increasing the number of days and participants will clarify the impact the time frame had on the generalisability of the conclusions on coupling and predictability. While the recruitment process and rate of participation could suggest that finding and keeping participants participating might be difficult, it should be noted that the participant's feedback was quite positive regarding the implementation and accessibility of the study. With possibly a wider range of access to the study (for example a phone or smartwatch app) and monthly incentives for participation, finding participants might get easier while keeping participants participating does not seem too difficult. Eliminating the limitations will not only put the results in perspective but might also offer the chance for more expansive setups. A windowed analysis of a longer time frame and possibly more participants would additionally offer the possibility to look for the interaction of short and long-term dynamics representing identity statuses as proposed by the landscape model of identity, and transitions between attractor states (Van der

Gaag, 2020). As the techniques show promising results, collecting better data to work with is key to exploring a complex dynamic system approach to identity.

Well-being has been purposefully picked, because as already mentioned it is well established within the identity literature as having a relationship with key identity variables (Meuss, 2011). Despite the methodological challenges of researching identity and its impact on our daily life using non-linear techniques, and despite the aforementioned limitations, the results are congruent with the established research. But the outcomes also partially support the suspicion that there is more to the relationships between identity variables and well-being than one linearly influencing the other. As research continues, more dynamic non-linear approaches toward identity variables and their impact should be considered. Understanding the process of how we identify ourselves, and develop commitments that could in turn impact resilience, happiness and well-being, could lead to more appropriate identity development strategies.

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