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A longitudinal network analysis of the relationship between love addiction, insecure attachment patterns, and interpersonal dependence

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Abstract

The present study employed a network analysis approach to explore interrelationships among love addiction, attachment anxiety, attachment avoidance, and interpersonal dependence. The sample included 80 couples ($N = 160$) in romantic relationships, assessed longitudinally through online self-reports at the study's initiation and three months later. The findings revealed that attachment anxiety correlated strongly with low self-confidence, attachment avoidance related to autonomy, and love addiction showed a positive association with emotional dependence but a negative association with attachment avoidance. These findings underscore the associations among love addiction, insecure attachment patterns, and dimensions of interpersonal dependence. Addressing the core link between love addiction and insecure attachment patterns may enhance the psychological well-being of both partners in a couple.

Keywords Attachment anxiety, Attachment avoidance, Interpersonal dependence, Love addiction, Network analysis

Introduction

Love addiction is categorized as one of the "new addictions," sharing similar psychopathological characteristics with substance dependence [1, 2]. It is defined as excessive dependence, obsession, and immersion in a romantic relationship, persisting even when the relationship detrimentally affects mental health and well-being [3]. Love addiction often leads to compulsive pursuits of material or non-material connections, often at the expense of emotional, interpersonal, occupational, financial, and legal well-being [4]. For instance, Acevedo and Aron demonstrated that romantic love can persist in healthy long-term relationships, characterized by intense affect and sustained sexual interest. However, love-related obsession predominantly occurs at the inception of relationships and is inversely correlated with satisfaction in long-term romantic bonds. Evidence suggests that love addiction is more strongly associated with stalking behavior among women than men [5]. Love addiction stems from poor emotional regulation and disorganized attachment patterns, with romantic attachments exhibiting addictive qualities akin to substance dependence [6]. For instance, romantic attachment to a deceitful, abusive, or manipulative partner can also constitute love addiction [7]. Furthermore, anxious-ambivalent attachment difficulties, equally prevalent among both genders, suggest a comparable prevalence of love addiction across

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genders [8, 9]. Mutuality in love can be visually represented in distinct ways. For instance, when one individual is intensely in love with another without reciprocation, the former may be characterized as exhibiting an addictive attachment. In contrast, when both partners display obsessive love towards each other, this dynamic is more appropriately classified as mutual obsession, rather than addiction [10].

Attachment theory posits that individuals develop various attachment styles based on early interactions with primary caregivers, and these styles persist into adulthood, influencing intimate relationships. Attachment anxiety and attachment avoidance are two prevalent styles, often considered indicators of attachment insecurity. These styles manifest as distinct emotional needs and coping mechanisms within intimate relationships [11]. Individuals exhibiting attachment anxiety typically experience insecurity regarding emotional safety in relationships, characterized by excessive dependence on and demands from their partners. They tend to worry about potential abandonment or a loss of affection, often displaying emotional over-dependence and insecurity [12]. A key feature of anxious attachment is the constant seeking of emotional reassurance, as individuals with this style frequently require attention and validation from their partners. This need may result in exaggerated emotional expressions and heightened sensitivity to their partner's responses. Conversely, attachment avoidance refers to individuals who tend to eschew excessive emotional reliance in intimate relationships. They often display emotional distance or coldness toward closeness, both emotional and physical. Those with avoidant attachment typically place high value on independence and may resist revealing vulnerabilities. When confronted with emotional needs, they may feel uncomfortable and perceive emotional intimacy as a threat [13]. Avoidant individuals often struggle to express dependence or seek help, maintaining emotional distance and avoiding excessive emotional investment.

Insecure attachment patterns persistently influence emotional regulation, intimate relationships, and social interactions across the lifespan. In adulthood, attachment styles significantly shape behaviors and emotional responses in both romantic relationships and parent–child interactions. Insecure attachment patterns profoundly affect behavioral addictions [14], evolving dynamically across the lifespan. As a result, love addiction—defined by obsession and dependency—is closely associated with insecure attachment patterns [1].

Insecure attachment, especially anxious attachment, plays a pivotal role in fostering behavioral addictions, including substance use and other addictive tendencies [15]. This association is frequently mediated by emotional dysregulation, as individuals with insecure attachment often struggle with emotional regulation, heightening their susceptibility to addictive behaviors [16]. Research indicates that insecure attachment patterns can both predict and result from long-term addictive behaviors, intensifying challenges in emotional regulation and interpersonal dynamics [17]. Studies on alcohol addiction reveal that individuals with insecure maternal attachment often face more severe mental health challenges and significant difficulties in emotional communication. This finding suggests that insecure attachment serves both as a contributing factor to addictive behaviors and as a potential outcome of addiction [18].

Interpersonal dependence, similar to attachment, represents a distinct personality dimension that significantly influences relational dynamics [19]. Dependency is a hallmark characteristic frequently observed among individuals undergoing psychotherapy. Although personality traits are generally regarded as stable across a lifetime, dependency behaviors exhibit variability, manifesting as dependence in certain relationships and independence in others. In the context of interpersonal dependency, self-confidence reflects an individual's sense of security and self-worth within a relationship. Individuals with high self-confidence are typically less reliant on their partners and can navigate relational challenges independently. Conversely, those with low self-confidence tend to depend more on their partner's validation and support. Autonomy refers to the ability to maintain personal independence and space within a relationship. Individuals with high autonomy are able to balance their personal needs with emotional dependency, although excessive autonomy may result in emotional distance. A balanced level of autonomy contributes to a healthy relational dynamic. Emotional dependence, on the other hand, indicates the extent to which an individual relies on their partner for emotional support. Individuals with high emotional dependence often require constant reassurance from their partner. While healthy emotional dependence can foster intimacy, excessive dependence may result in insecurity and anxiety, potentially destabilizing the relationship. These three dimensions—self-confidence, autonomy, and emotional dependence—offer insight into an individual's behavioral patterns in intimate relationships and highlight the delicate balance between dependency and independence, as well as their impact on emotional well-being [20].

In therapeutic contexts, dependency often manifests as emotional reliance on the therapist, with individuals excessively depending on their guidance and advice. This dependency may extend beyond therapy sessions, with clients seeking the therapist's support and decision-making assistance in various aspects of their lives. While

dependency is, to some degree, a natural part of the therapeutic process—especially in its early stages when trust and emotional safety are being established—excessive dependency can hinder the development of the patient's independence and self-efficacy. Such over-reliance can impede personal growth and negatively affect treatment outcomes [21, 22].

Nonadaptive and adaptive codependency represent contrasting dynamics within relationships. Nonadaptive codependency involves excessive emotional reliance on another person, where one individual may prioritize the needs of their partner to the detriment of their own. This often leads to a loss of personal identity, neglect of self-care, and difficulties in establishing healthy boundaries [20]. Such an unhealthy dynamic is frequently linked to poor self-esteem, chronic anxiety, and a tendency to become overly entangled in the partner's problems. In contrast, adaptive codependency represents a healthier form of interdependence, where individuals support one another without compromising their own well-being [23]. In adaptive codependent relationships, partners foster each other's emotional growth while maintaining their individual independence.

Understanding these dynamics is crucial for identifying unhealthy relationship patterns and promoting more balanced, mutually supportive relationships.

Zuroff and Fitzpatrick (1995) [24] identified a relationship between codependency and anxious attachment in two studies examining college students engaged in serious romantic relationships. McBride (2006) [25] proposed that nonadaptive codependency aligns with insecure attachment, whereas adaptive codependency is associated with secure attachment. The findings, which were inconclusive, indicated significant associations between both adaptive and nonadaptive codependency and all attachment styles across clinical and nonclinical populations. These findings highlight the intricate relationship between attachment styles and interpersonal dependence.

Although insecure attachment and codependency exhibit overlapping behavioral patterns, they do not always co-occur. Individuals with secure attachment, formed during childhood, are less susceptible to disruptions in attachment development during adulthood. In contrast, children with insecure attachment styles—particularly anxious or preoccupied attachments—often extend their difficulties with specific attachment figures to broader interpersonal challenges, which are rooted in dependency [26].

Network analysis is a dynamic methodological process rather than a static one. By examining changes in symptom interrelationships within a disorder, it offers profound insights into mechanisms driving resistance or progression [27]. From a network perspective, love addiction, insecure attachment patterns, and interpersonal dependence are conceptualized as emergent phenomena arising from reciprocal interaction systems. Network analysis provides a robust framework for examining these intricate relationships. This approach enables the computation of centrality indices to identify symptoms most interconnected within the network, thereby highlighting their potential causal roles and warranting further investigation [28].

In social psychology, network analysis examines the structure of social relationships within groups, encompassing interpersonal relationships, social interactions, and group dynamics. This method elucidates how interpersonal interactions shape individuals' psychological states and behaviors [29]. Network analysis is also utilized to construct "symptom networks" in mental health, exploring interrelationships among symptoms of psychological disorders. For instance, symptoms of depression are conceptualized as interconnected nodes, with network analysis revealing how these symptoms interact and influence each other [27]. This methodology enables psychologists to identify key factors and therapeutic targets within symptom networks more effectively.

Additionally, network analysis elucidates interactive relationships among emotional states. For example, emotional states are modeled as interconnected nodes, facilitating the study of transitions and dependencies among various emotions [30]. Longitudinal network analysis is extensively applied in mental health research, particularly to study symptom networks in disorders such as depression and anxiety [31]. By leveraging longitudinal data, researchers can monitor symptom changes over time and examine their mutual influences. For instance, in depression symptom networks, interrelationships among symptoms such as mood, sleep, and appetite evolve over time. Longitudinal network analysis sheds light on these changes and their implications for treatment outcomes [32].

Longitudinal network analysis also examines emotional and behavioral changes by observing network structures at multiple time points. This approach identifies patterns of emotional fluctuation or behavioral evolution and highlights potential driving factors and trajectories [33]. Compared to cross-sectional analysis, which examines static data, longitudinal network analysis offers deeper insights into causal mechanisms and long-term changes. This perspective is crucial in psychological research, where tracking changes in symptoms, emotions, and interpersonal relationships is essential [34]. In the study of complex system evolution, longitudinal network analysis elucidates how individual behaviors or symptoms develop through interactions among multiple factors,

thereby laying the groundwork for more effective interventions. Longitudinal network analysis is a method that examines the interactions between multiple factors. The research in this paper focuses on the relationships among these factors, and longitudinal network analysis allows for the exploration of how the influence of these factors evolves over time.

Love addiction, insecure attachment patterns, and interpersonal dependency are closely interconnected, collectively shaping individuals' behavioral patterns and emotional experiences in intimate relationships. Love addiction is characterized by excessive dependency and obsession within relationships, where individuals find it difficult to detach, even when they recognize the harmful nature of the relationship [35]. This condition often stems from difficulties in emotional regulation and disruptions in attachment patterns. Individuals with insecure attachment styles, particularly those with anxious attachment, are especially vulnerable to developing love addiction.

Insecure attachment patterns, including anxious and avoidant attachment, are typically characterized by heightened dependency on others and excessive emotional needs, which complicate the maintenance of healthy interpersonal relationships. Individuals with these attachment styles often struggle to manage emotional fluctuations, leading to unrealistic expectations and demands within intimate relationships. In particular, individuals with anxious attachment tend to exhibit excessive dependence on their partners due to fears of abandonment, potentially perpetuating a cycle of love addiction [36].

Interpersonal dependency refers to an excessive reliance on others within specific relationships, often closely linked to attachment styles. Highly dependent individuals frequently display behaviors that reflect excessive reliance on their partners, struggle to address emotional issues independently, and may become ensnared in unhealthy relationships [12]. The interplay among love addiction, insecure attachment, and interpersonal dependency forms a complex psychological mechanism, preventing individuals from breaking free of dependency behaviors and emotional entanglements.

In summary, while love addiction is closely associated with insecure attachment patterns, longitudinal research on love addiction remains limited. Although insecure attachment patterns and interpersonal dependence are known to be interlinked, research on the evolving network structure of these three factors over time is scarce. Leveraging the capabilities of network analysis, the present longitudinal study was designed to (a) identify the central symptoms of love addiction, (b) examine the linkages among the three factors, and (c) evaluate their dynamic interrelationships. Through a preliminary reading of the literature, it was therefore assumed that love addiction would be linked to insecure attachment patterns and interpersonal dependence. Hypothesis: love addiction is associated with insecure attachment patterns, interpersonal dependence.

Methodology

Participants

The questionnaires were collected between June and October 2023, targeting couples in romantic relationships, The duration is three months [37]. At Time 1, 180 questionnaires were distributed, and 90 couples completed the first round of the survey. At Time 2 (three months later), 80 couples, corresponding to 160 completed questionnaires, participated in the study. Ten couples who did not complete the second survey were excluded due to relationship dissolution during the study period. This study passed the ethical review of the Ethics Committee of the School of Public Health of Dalian Medical University, and every participant signed the informed consent form.

The final sample comprised 80 couples ($N=160$), with an equal distribution of males (50%) and females (50%). Participants were recruited from a university, and the questionnaires were administered through an online platform. All participants reviewed an informed consent form and provided their consent before completing the questionnaire. The Demographic Characteristics are presented in Table 1.

Questionnaire

Love addiction questionnaire-short form

The Relationship Addiction Scale-Short Form, a six-item self-report measure, was developed by Costa et al. (2021) [38] to assess behavior-based addictions. This study utilized a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Higher scores on the scale indicate greater levels of love addiction. The scale demonstrated good internal consistency in this sample, with Cronbach's alpha values of 0.868 at Time 1 and 0.862 at Time 2. Details of the Love Addiction Questionnaire-Short Form are presented in Table 2.

Table 1 The demographic characteristics

	Category	Quantity	Percentage
Gender	Male	80	50.0%
Age	Female	80	50.0%
	Age (Mean)	22.06	
	Age (Median)	22	
Education	Undergraduate	129	80.6%
	Master	31	19.4%

Table 2 Questionnaire title

Love addiction	Feel the urgent need to be with your partner		
	Feel depressed in your partner's absence		
	Feel the need to increase the time spent together with your partner to feel relaxed		
	Stay with your partner to relieve stress		
	Not reduce the time spent with your partner		
	Neglect time studying or working to be in the relationship with your partner		
Attachment pattern	I trust other people and I like it when other people can rely on me		
	I feel at ease in intimate relationships		
	I think it is important that people can rely on each other		
	I would like to be open to others, but I feel I can't trust other people		
	I would like to have close relationships with other people, but I find it difficult to fully trust them		
	I'm afraid that my hopes will be deceived when I get too closely related to others		
	I am wary to get engaged in close relationships because I'm afraid to get hurt		
	I feel uncomfortable when relationships with other people become close		
	I often wonder whether people like me		
	I am often afraid that other people don't like me		
	I don't worry whether people like me or not		
	It is important to me to be independent		
	I prefer that others are independent of me, and that I am independent of others		
	I like to be self-sufficient		
	I don't worry about being alone: I don't need other people that strongly		
Interpersonal Dependence	Emotional Reliance	ER1	I would be completely lost if I didn't have someone special
		ER2	I get upset when someone discovers a mistake I've made
		ER3	I must have one person who is very special to me
		ER4	I need to have one person who puts me above all others
		ER5	I would feel helpless if deserted by someone I love
	Lack of Social Self-confidence	LSC1	I would rather be a follower than a leader
		LSC2	I feel confident of my ability to deal with most of the personal problems I am likely to meet in life
		LSC3	In an argument. I give in easily
		LSC4	In social situations, I tend to be very self-conscious
		LSC5	I have a lot of trouble making decisions by myself
		LSC6	I don't like to buy clothes by myself
		LSC7	I don't have what it takes to be a good leader
	Assertion of Autonomy	AOA1	I prefer to be by myself
		AOA2	I don't need other people to make me feel good
		AOA3	I don't need much from people
		AOA4	When I am sick. I prefer that my friends leave me alone
		AOA5	I don't need anyone

Attachment style-short form

The scale is a 15-item self-report measure designed to assess two domains of attachment style—attachment anxiety and attachment avoidance—through four dimensions: "secure," "fearful avoidance," "preoccupied," and "dissociative." Secure attachment corresponds to low anxiety and low avoidance; anxious attachment (preoccupied) corresponds to high anxiety and low avoidance; fearful avoidance corresponds to high anxiety and high avoidance; and avoidant attachment (dissociative) corresponds to low anxiety and high avoidance. Attachment anxiety is characterized by a combination of "security + dissociative—fearful avoidance—preoccupied," while attachment avoidance is defined by "security + preoccupied—dissociative—fearful avoidance." High and low levels of attachment anxiety and avoidance are determined by calculating the average values of these dimensions [39].This study employs a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). As the four attachment styles were assessed using individual items. The questionnaire demonstrated good reliability in previous research [40]. Details of the Attachment Style-Short Form are presented in Table 2. The Cronbach's alpha values were 0.70 at Time 1 and 0.842 at Time 2.

Interpersonal dependency scale

For this study, 17 items were selected: 5 items for Emotional Reliance, 7 items for Lack of Social Self-confidence, and 5 items for Assertion of Autonomy. The selected items had the highest factor loadings in the analysis conducted by Loas et al. (1998) [40], aiming to minimize construct overlap and enhance the reliability and validity of the measure. This study utilizes a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The scale demonstrates good internal consistency in this sample, with Cronbach's alpha values of 0.789 at Time 1 and 0.888 at Time 2. Details of the Interpersonal Dependency Scale are presented in Table 2.

Data analysis

Statistical analysis is conducted using SPSS 25 and RStudio 4.3.1, incorporating the R packages "qgraph" [41, 42], "bootnet" [43], and "NetworkComparisonTest". Descriptive statistics are computed, and the paired samples t-test is used to evaluate the significance of differences in relationship addiction between the two time periods.

Network analysis

All networks are visualized as nodes within a weighted network, where edges represent regularized partial correlations connecting the nodes. The thickness of the edges indicates the strength of the links (i.e., effect size), with red representing negative correlations and green representing positive correlations. Each distinct dimension, such as Anxiety, is depicted as a node, while the connections between dimensions are represented by the thickness of the edges. Thicker edges denote a higher degree of association between dimensions. The differences between the two time periods were analyzed using longitudinal network analysis. In this analysis, the thickness of the paths represents the strength of the associations, while variations in the path colors indicate the positive or negative nature of the relationships. By comparing the network analysis graphs from the two time periods, it becomes more intuitive to observe the changes in the nodes over time.

Centrality estimation

Two centrality indices, strength and closeness, are calculated and chosen for reporting in this study. The strength index reflects the relative importance of a node within the network, independent of the total number of its connections. For instance, if the node Anxiety exerts a stronger influence on other nodes, its strength index will be higher. Hence, a higher strength value indicates a greater ability of the node to influence other nodes.

The closeness index pertains to the total number of indirect connections of a node, providing insight into how quickly the node responds to changes in other nodes. Notably, strength reflects directional connections, while closeness represents indirect connections [44]. In the absence of negative correlations within the network, strength is considered a more reliable centrality measure, defined as the sum of the absolute edge weights of a node's connections [45].

Stability estimation

Given that the estimated network model is influenced by sampling variations, it is essential to evaluate the accuracy and stability of edge weights and centrality indices [46]. Parameter estimates derived from resampled data were used to construct 95% confidence intervals through resampling with replacement [46]. The stability of the two networks was assessed by calculating centrality stability coefficients (CS), derived from deleted subsets of nonparametric cases applied to weighted edges (Nboots = 1,000). Epskamp et al. (2018) recommended that CS coefficients should exceed 0.5 but not fall below 0.25.

Network comparison

The Network Comparison Test evaluates differences in network structure between two estimation models through an alignment test. The invariance of global strength and edge weights was assessed to distinguish differences between global and local network features. Global weights were defined as the sum of all edge weights within the network [47].

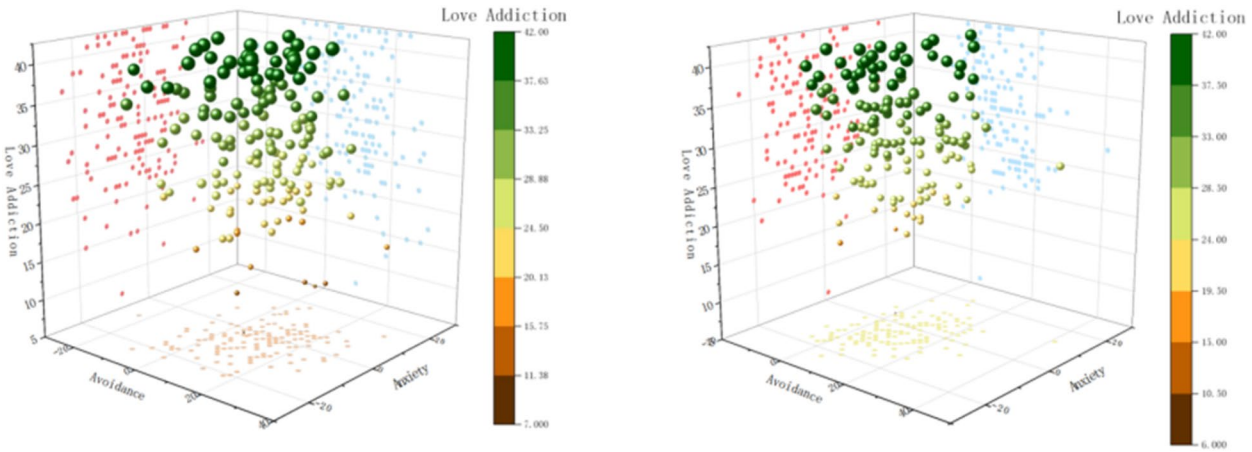

Fig. 1 3D scatterplot of love addiction levels. Note: The left scatterplot is Time1, the right scatterplot is Time2

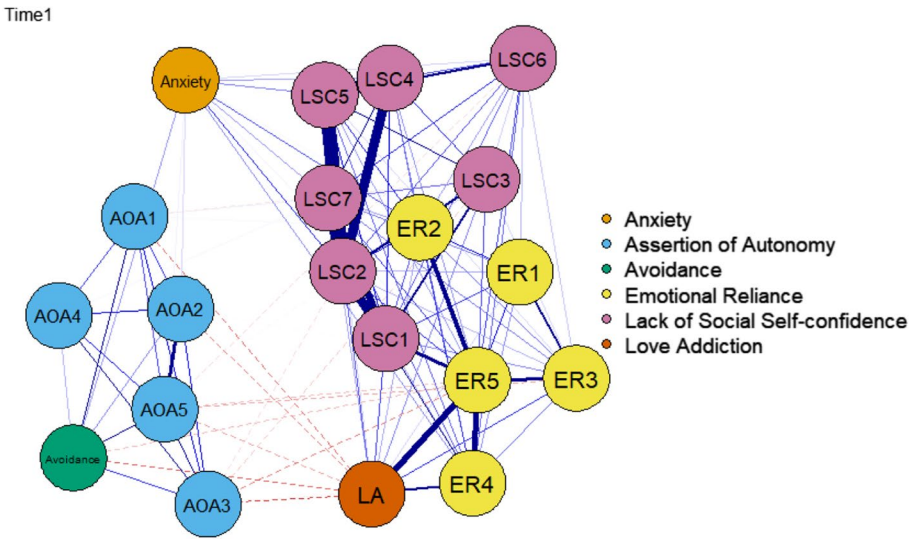

Fig. 2 Time1 network analysis. Note: Thicker edges between symptoms indicate stronger associations

Results

Descriptive analysis of love addiction

In this study, a paired samples t-test is used to assess the significance of the difference in love addiction levels between Time 1 and Time 2. As illustrated in Fig. 1, a 3D scatter plot is created to clearly visualize the distribution of love addiction levels. Based on the scatterplot it can be seen that there is a variation in relationship addiction and that this variation is statistically significant, we will then take the next step in our research by analyzing the network to find out the influencing factors related to love addiction.

Network estimation

Figure 2 shows the network estimation for Time 1. Love addiction exhibits a strong positive correlation with ER5(I would feel helpless if deserted by someone I love.) (edge weight 0.52) and ER4(I need to have one person who puts me above all others.) (edge weight 0.43), and a negative correlation with attachment avoidance (edge weight −0.30). Attachment anxiety is negatively correlated with LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.) (edge weight 0.36) and ER2(I get upset when someone discovers a mistake I've made.)

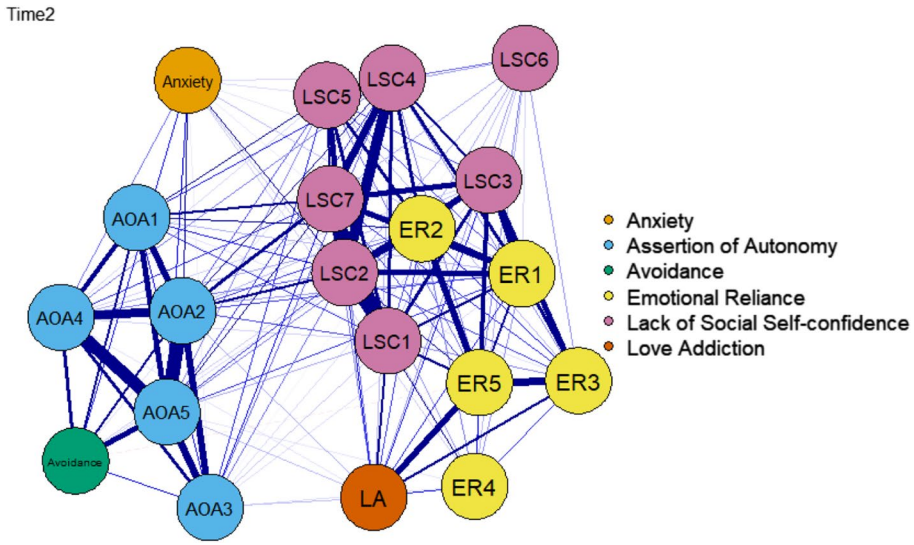

Fig. 3 Time2 network analysis. Note: Thicker edges between symptoms indicate stronger associations

(edge weight 0.31). Attachment avoidance is negatively correlated with AOA1(I prefer to be by myself.) (edge weight 0.40) and AOA5(I don't need anyone.) (edge weight 0.41), as well as with ER5(I would feel helpless if deserted by someone I love.) (edge weight −0.21).

Figure 3 shows the network estimation for Time 2. Love addiction is strongly positively correlated with ER5(I would feel helpless if deserted by someone I love.) (edge weight 0.55) and ER3(I must have one person who is very special to me.) (edge weight 0.45), and negatively correlated with attachment avoidance (edge weight −0.11). Attachment anxiety is negatively correlated with LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.) (edge weight 0.40) and AOA2(I don't need other people to make me feel good.) (edge weight 0.40). Attachment avoidance is negatively correlated with AOA5(I don't need anyone.) (edge weight 0.52), AOA4(When I am sick. I prefer that my friends leave me alone.) (edge weight 0.48), and ER5(I would feel helpless if deserted by someone I love.) (edge weight −0.17).

Estimation of centrality

To provide a more visual comparison of centrality, this study ranks the symptoms by value, as shown in Fig. 4. At Time 1, LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.), LSC7(I don't have what it takes to be a good leader.), and LSC1(I would rather be a follower than a leader.) exhibited the highest strength, and the centrality difference test confirmed that these three symptoms had significantly higher strengths compared to the others. At Time 2, LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.), LSC7(I don't have what it takes to be a good leader.), and LSC1(I would rather be a follower than a leader.) maintained the highest strength, indicating the stability of their influential effects over time. Notably, AOA4(When I am sick. I prefer that my friends leave me alone.), Attachment Avoidance, and Attachment Anxiety had the lowest strengths at Time 1, with Attachment Anxiety and Attachment Avoidance remaining low at Time 2.

Centrality intensity highlights the central effects within the comorbidity network, and interventions aimed at these central symptoms can reduce overall severity. At Time 1, love addiction and ER5(I would feel helpless if deserted by someone I love.) exhibited the highest strength in LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.). At Time 2, closeness exhibited the highest strength in LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.), LSC7(I don't have what it takes to be a good leader.), and LSC4(In social situations, I tend to be very self-conscious.). Strength differences are presented in Fig. 5, while closeness differences are shown in Fig. 6. The edge intensity differences are depicted in Fig. 7.

Network analysis reveals that, at different time points, love addiction is strongly associated, both directly and indirectly, with factors such as lack of social self-confidence, emotional reliance, and assertion of autonomy. These factors are components of interpersonal dependency, suggesting a strong relationship between love addiction and interpersonal dependency. The three dimensions of relationship dependence provide a deeper

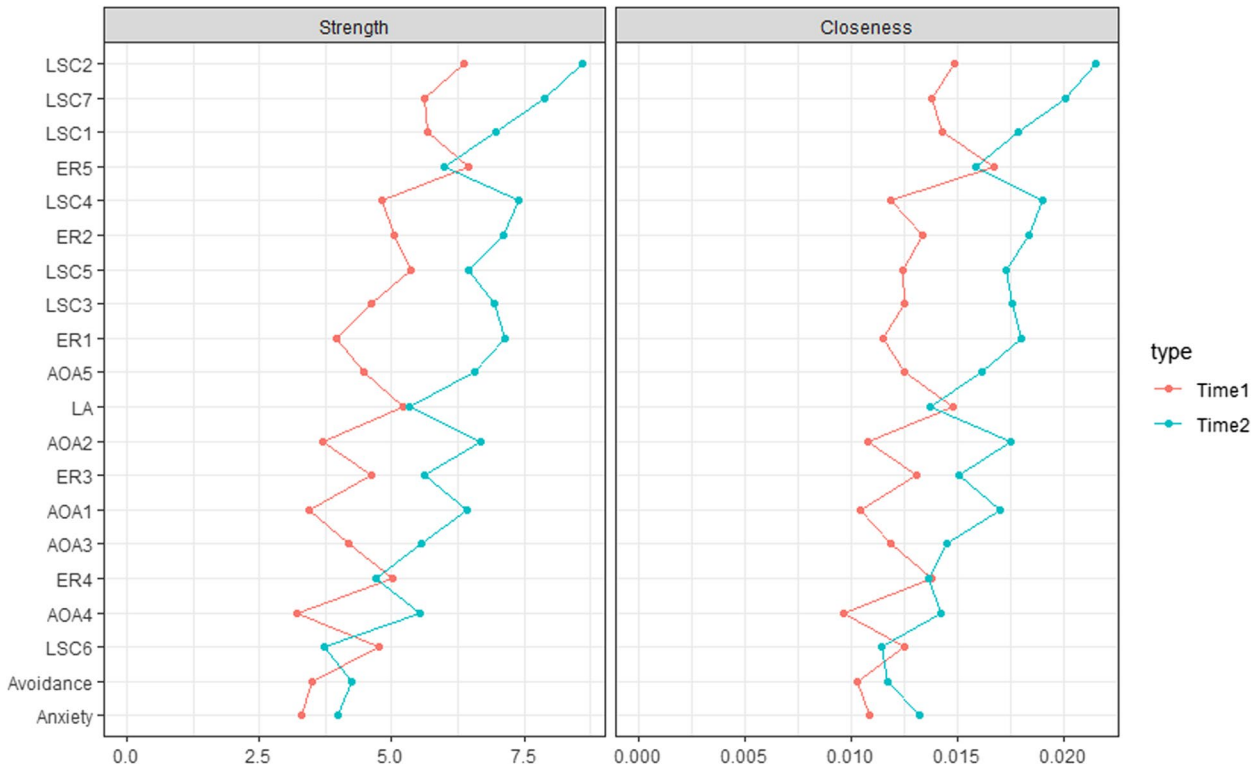

Fig. 4 Strength and closenness of Time1 and Time2

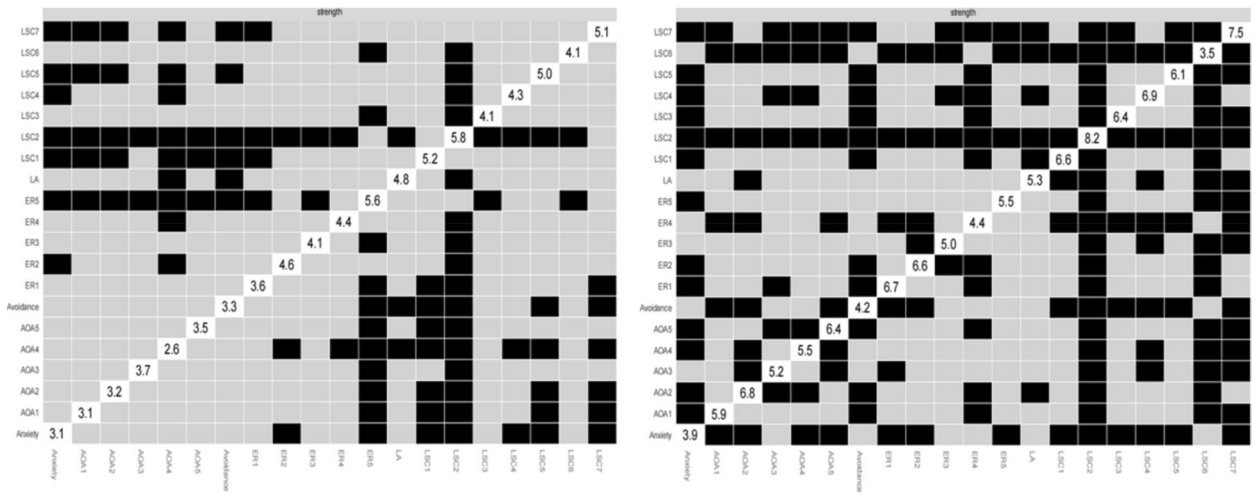

Fig. 5 Strength differences. Note: The black grid represents a significant difference between the two corresponding edge weights, while the gray grid indicates no significant difference. The two grids on the left show the results of the strength difference test at Time 1, and the grid on the right presents the results at Time 2

understanding of their individual contributions to relationship addiction. This framework sets the stage for further discussion, allowing for a more comprehensive analysis of how each dimension influences relationship addiction.

Accuracy and stability estimation

Figure 8 presents the confidence intervals for edge weights estimated through bootstrapping. Narrower confidence intervals indicate acceptable accuracy. Figure 9 displays the results of the central stability

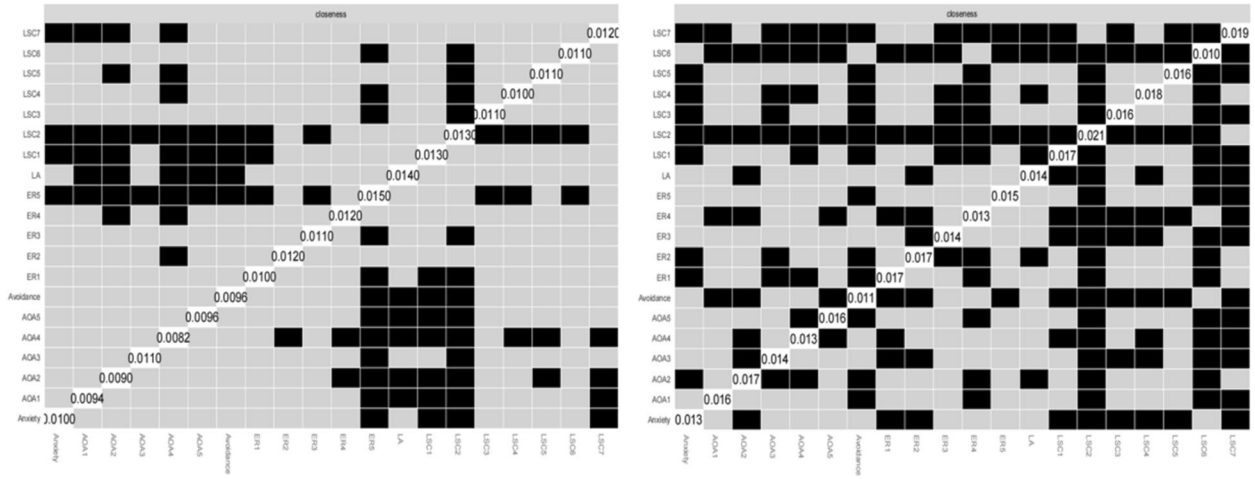

Fig. 6 The closeness differences. Note: The black grid indicates a significant difference between the two corresponding edge weights, and the gray grid indicates no significant difference. The left two are the results of the closeness difference test at Time1, and the right are the results of the closeness difference test at Time2

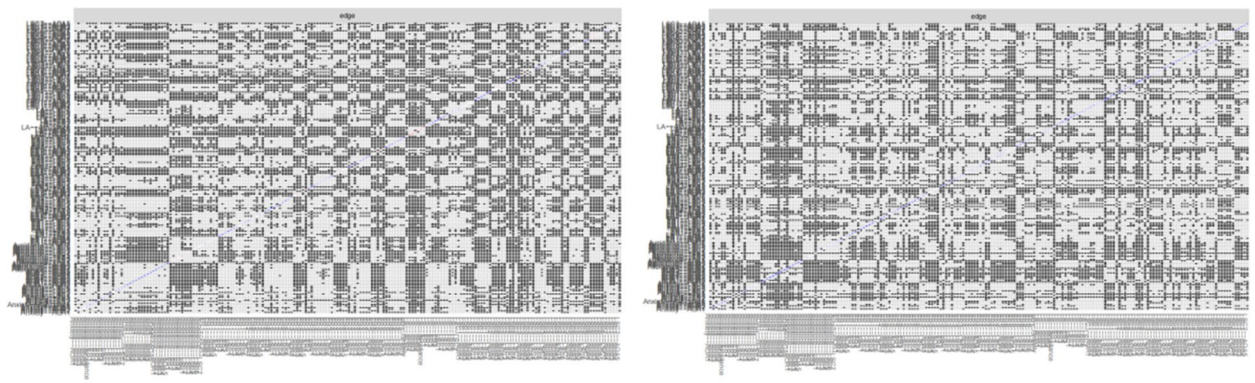

Fig. 7 The edge weights. Note: The black grid indicates that there is a significant difference between the two corresponding edge weights, and the gray grid indicates that there is no significant difference. The left two are the results of the edge strength difference test at Time1, and the right one is the results of the edge strength difference test at Time2

estimation process. The strength coefficients and affinities for the CS are 0.44 and 0.44 at Time 1, and 0.68 and 0.60 at Time 2, respectively. These values suggest that they are reliable measures of the network node characteristics [48].

Network comparison

This study compares the global and local structures of the Time 1 and Time 2 networks. The results reveal no differences across all measures ($p = 0.61$). However, significant differences are found between the edges. Attachment anxiety shows an increased negative correlation with ER3(I must have one person who is very special to me.) (Time1 edge weight −0.04, Time2 edge weight −0.15, $p < 0.05$). ER3(I must have one person who is very special to me.) exhibits a stronger linkage with LSC3 (In an argument. I give in easily.)(Time1 edge weight 0.19, Time2 edge weight 0.53, $p < 0.05$), and attachment anxiety also shows a stronger linkage with LSC6(I don't like to buy clothes by myself.) (Time1 edge weight 0.19, Time2 edge weight 0.06, $p < 0.05$). LSC2(I feel confident of my ability to deal with most of the personal problems I am likely to meet in life.) has a stronger linkage with LSC7(I don't have what it takes to be a good leader.) (Time1 edge weight 0.60, Time2 edge weight 0.61, $p < 0.05$), and LSC5(I have a lot of trouble making decisions by myself.) is more strongly linked with AOA1(I prefer to be by myself.) (Time1 edge weight 0.02, Time2 edge weight 0.41, $p < 0.05$). Additionally, love addiction has stronger linkages with AOA2(I don't need other people to make me feel good.) (Time1 edge weight −0.27, Time2 edge weight 0.23,$p < 0.01$), AOA3(I don't need much from people.) (Time1 edge weight −0.33, Time2 edge weight

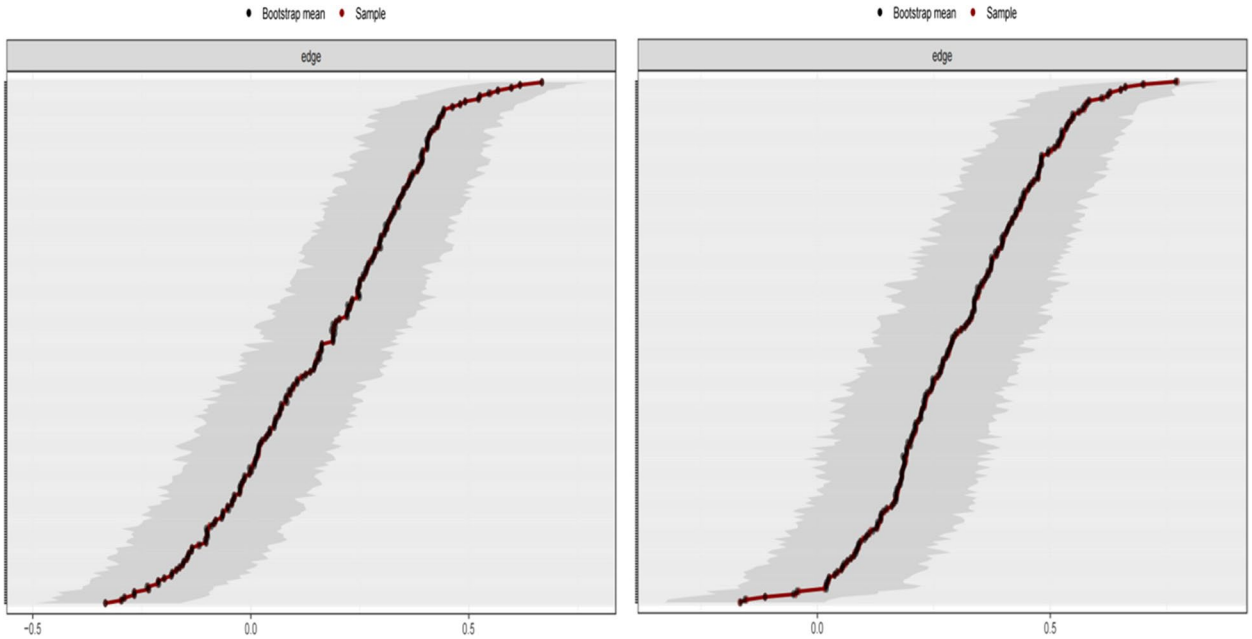

Fig. 8 Narrower confidence intervals indicate reliable accuracy. Note: On the left are the accuracy test results for Time1 and on the right are the accuracy test results for Time2

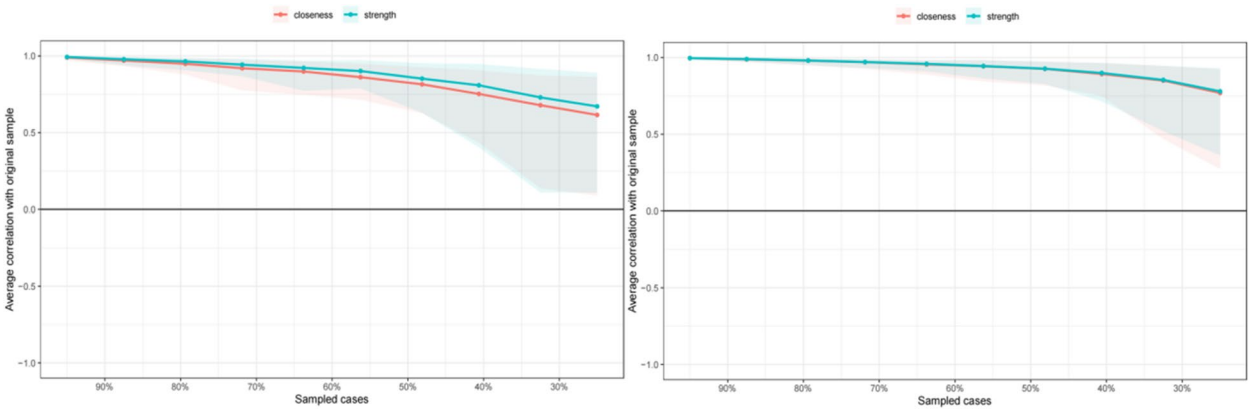

Fig. 9 Centrality index for stability estimation. Note: On the left are the results of the stability test at Time1 and on the right are the results of the stability test at Time2

0.21,$p < 0.01$), and AOA5(I don't need anyone.) (Time1 edge weight −0.23, Time2 edge weight 0.21,$p < 0.05$).

Notably, love addiction is negatively associated with AOA2(I don't need other people to make me feel good.), AOA3(I don't need much from people.), and AOA5(I don't need anyone.) at Time 1, but positively associated with these factors at Time 2. The association between AOA3(I don't need much from people.) and LSC5(I have a lot of trouble making decisions by myself.) (edge weight 0.35, $p < 0.01$), as well as LSC7(I don't have what it takes to be a good leader.) (edge weight 0.39,$p < 0.05$), is strengthened, and the connectivity between AOA2(I don't need other people to make me feel good.) and AOA5(I don't need anyone.) is also enhanced (edge weight 0.77, $p < 0.05$).

Discussion

The present study examines the impact of love addiction, insecure attachment patterns, and interpersonal dependence over time through a web-based analysis. The longitudinal study finds that love addiction is strongly related to autonomy assertion and emotional dependence, exhibits a strong positive correlation with ER3 ("I must have one person who is very special to me")and ER5 ("I would

feel helpless if deserted by someone I love"). Exhibits a strong negative correlation with AOA2 ("I don't need other people to make me feel good"), AOA3 ("I don't need much from people"), and AOA5 ("I don't need anyone") being the most strongly associated. Attachment anxiety is strongly associated with a lack of social self-confidence, with LSC6 being the most closely related. In contrast, attachment avoidance is closely related to autonomy assertion.

Love addiction and emotional dependency

At Time 1, the relationship between Love Addiction (orange node) and Emotional Dependency (yellow node, ER) is already strong, as shown by multiple thick lines directly connecting Love Addiction with ER1 ("I would be completely lost if I didn't have someone special"), ER2 ("I get upset when someone discovers a mistake I've made"), and ER4 ("I need to have one person who puts me above all others"). This suggests that Love Addiction and Emotional Dependency are closely related at Time 1. Furthermore, the relationship between Love Addiction and Emotional Dependency grew more complex and intensified. Both the number and thickness of the connections increased, particularly with new significant connections involving ER3 ("I must have one person who is very special to me") and ER5 ("I would feel helpless if deserted by someone I love"). This suggests that the dimensions of Emotional Dependency have a more comprehensive influence on Love Addiction. Based on the edge weights, it is evident that each aspect of Love Addiction and Emotional Dependency is strongly linked at both Time 1 and Time 2. Love addicts often experience negative emotional states when apart from their partner, coupled with a strong need and desire to be with them [1]. Love addicts frequently feel inadequate and unworthy of love, living in constant fear of abandonment by their partner. The fear of abandonment leads love addicts to attempt greater control over others; they feel the need to stay with their partner at all times and may sacrifice themselves to maintain the relationship. Griffiths' (2005) [49] "component" model of addiction identifies key components that constitute love addiction. One such component is the state of withdrawal, referring to the typical psychological and physical symptoms that occur in the absence of a loved one. Network analysis reveals that, at Time 1, love addiction was negatively correlated with autonomy; that is, higher autonomy was associated with lower levels of love addiction. As individuals with high love addiction become more autonomous, they become less dependent on their partner and exhibit greater calmness. They will behave differently, becoming less emotionally dependent and returning to their life and studies. Moreover, when their partner is not present, they will no longer feel as low or uncomfortable as before [50]. When their partner left, they will feel more confident, thinking they had found a better partner, and will no longer attributed all their mistakes to themselves as they did before [11].

Love addiction and insecure attachment patterns

Anxiety and Avoidance represent the two primary dimensions of insecure attachment patterns. At Time 1, the network reveals a moderate connection between Love Addiction (LA) and Anxiety. The thickness of the line between LA and Anxiety suggests that emotional turmoil associated with anxiety plays a significant role in fueling love addiction. This connection reflected how individuals with love addiction often experience heightened emotional dysregulation, which could manifest as anxiety when their romantic needs are unmet [51]. At Time 2, the connection between LA and Anxiety becomes slightly weaker. This reduction suggests that, over time, individuals with love addiction may develop emotional resilience or coping mechanisms to manage their anxiety. Alternatively, it could indicate a shift in the centrality of other variables, such as Emotional Reliance (ER), which seems to play a more dominant role at Time 2. The diminished link between LA and Anxiety suggests that therapeutic interventions or changes in relational dynamics might help individuals with love addiction manage their anxiety more effectively over time [52]. However, anxiety continues to be a relevant factor in perpetuating addictive relational patterns.

At Time 1, the relationship between Love Addiction (LA) and Avoidance is weak, as indicated by thinner connecting lines. This suggests that individuals with love addiction are typically less avoidant and more inclined to seek closeness, often in a compulsive manner [53]. Avoidance, functioning as a defense mechanism, contrasts sharply with the dependency-driven behaviors characteristic of love addiction. At Time 2, the connection between LA and Avoidance slightly increases but remains relatively weak compared to other factors, such as Emotional Reliance or Lack of Social Self-confidence [54]. This suggests a nuanced shift, where individuals with love addiction may develop avoidant tendencies in response to repeated emotional disappointments or relationship failures. The slight increase in the relationship between LA and Avoidance may represent a protective adjustment. Over time, individuals struggling with love addiction may adopt avoidant traits to shield themselves from emotional pain, even if their underlying dependency needs remain unmet.

Attachment anxiety and self-confidence

In the network analysis, the association between Attachment Anxiety (yellow node) and Lack of Social

Confidence (pink node) significantly strengthened at Time 2, as indicated by the increased number of connections and thicker edges. Attachment anxiety generally reflects an individual's excessive concern about acceptance by others and intimacy in relationships. The strengthened relationship between attachment anxiety and lack of social confidence may suggest that individuals face greater emotional challenges when seeking social support. Attachment anxiety can diminish the quality and effectiveness of social interactions, leading to reduced social confidence [11]. Over time, this anxious state may become further entrenched, as reflected in the denser connections between network nodes. Studies analyzed the relationship between assertiveness and attachment have shown that secure attachment styles were associated with higher levels of assertiveness compared to insecure attachment styles [1]. Insecure attachment styles are associated with lower levels of self-confidence and self-concept clarity. Individuals with insecure attachment are less effective in establishing and maintaining a secure foundation in relationships, leading to lower relationship satisfaction, increased conflict, and diminished self-confidence. A longitudinal analysis revealed an increased correlation between attachment anxiety and LSC6 ("I don't want to buy clothes alone"), with a significant difference [55]. When experiencing attachment anxiety, individuals feel an urgent need for others to accompany them. They often feel lonely and isolated, fearing that their partner might communicate with others or even cheat in their absence [56]. Individuals with insecure attachment typically experience feelings of mistrust and low self-confidence, often resorting to maladaptive coping strategies when faced with stress. In distressing situations, they seek proximity to attachment figures, struggle to separate from them, and find it difficult to recover from troubling experiences [57]. Over time, the relationship between individuals with attachment anxiety and their partners tends to become more intimate. This change is often marked by an increase in the emotional needs of individuals with anxious attachment, particularly when they perceive emotional threats or insecurity. As the relationship progresses, individuals with attachment anxiety may become more dependent on their partners to meet these emotional needs. While this dependency may be evident early on, it typically intensifies over time. Research indicates that in long-term relationships, companionship and intimate interactions help individuals with attachment anxiety gradually establish emotional security [36]. For example, when a partner provides consistent and predictable emotional responses, the emotional fluctuations of individuals with anxious attachment may decrease, thus deepening the relationship. This process not only strengthens the emotional bond between partners but can also lead to a shift in the attachment style of the anxious individual, enabling them to handle conflicts and needs in intimate relationships in a healthier way. As time progresses, the emotional needs of individuals with attachment anxiety are increasingly met, which enhances the stability and intimacy of the relationship, ultimately guiding it toward a healthier and closer dynamic [58]. However, this development is contingent upon the active involvement of the partner, particularly in their ongoing efforts to provide emotional support and a sense of security. Self-confidence is strongly negatively correlated with anxiety [59]. Therefore, individuals experiencing high attachment anxiety should focus on improving assertiveness to alleviate the lack of it. When more assertive, individuals are less likely to feel that their partner does not love them enough or fear that their partner will leave them. Individuals with attachment anxiety often overreact to gain their partner's attention or keep them; however, such overreactions may push their partner away, further increasing their insecurity and anxiety [60]. The interaction between attachment anxiety and attachment security is particularly important in these types of relationships. Research indicates that when one partner exhibits attachment anxiety and the other is securely attached, the emotional stability and support provided by the secure partner can help mitigate the anxious partner's emotional fluctuations [61]. This "buffering effect" alleviates the anxious partner's dependency, enhancing their emotional security and promoting a healthier, more stable relationship. However, the attachment style of the addict's partner—especially if the partner is securely attached—can significantly influence the addict's behavior. Studies suggest that securely attached partners tend to offer subtle support, which helps avoidant individuals feel accepted without feeling pressured [62]. This type of support can reduce the anxiety typically experienced by avoidant individuals in intimate relationships and may improve their emotional health to some extent. Thus, the attachment style of the partner, particularly when the partner is securely attached, plays a positive role in the emotional recovery of individuals struggling with addiction. Our findings indicate that individuals with high attachment anxiety exhibited increased insecurity over time, while those with higher self-confidence experienced a buffering effect that reduced the negative impact of attachment avoidance. These results suggest that self-confidence acts as a key moderator in the relationship between attachment anxiety and relationship stability. This aligns with previous research but offers a novel contribution by illustrating how this buffering

effect unfolds across different time points in romantic relationships [63].

Attachment avoidance and autonomy

From a network structural perspective, the connection between Attachment Avoidance (green node) and Assertion of Autonomy (blue node) strengthened at Time 2, suggesting that individuals with avoidant attachment tendencies may be more inclined to pursue autonomy. Avoidant attachment is typically associated with reluctance toward intimate relationships, and individuals may reinforce their autonomy to reduce dependence on others. This tendency may relate to the "need for autonomy in relationships," where individuals seek to avoid the risks of dependence by reinforcing their sense of autonomy [64]. The significant involvement of AOA2 ("I don't need other people to make me feel good") and AOA5 ("I don't need anyone") in the network suggests that this dynamic mechanism is more pronounced at Time 2. Maintaining autonomy in intimate relationships is challenge, as the interdependence inherent in such relationships can infringe on an individual's personal needs and goals [65]. For individuals high in attachment avoidance, self-sufficiency is prioritized [66]. Intimate relationships differ from hierarchically structured relationships in that intimate partners are highly dependent on each other for basic needs, which can challenge feelings of autonomy. Individuals high in attachment avoidance fear intimacy and are distrustful of others' intentions [67]. Avoidant individuals manage these concerns by defensively minimizing attachment and prioritizing their own needs [67]. Highly avoidant individuals avoid contact to prevent harm, and when others rely on them, they tend to reject these individuals. Highly avoidant individuals perceive any dependent behavior as a threat to their autonomy [68]. The need to avoid dependence and maintain independence is a key reason why avoidant individuals are often disengaged in their relationships [69].

The interdependence inherent in intimate relationships can challenge autonomy, particularly for individuals with high attachment avoidance. Highly avoidant individuals tend to develop a higher level of "autonomy" in relationships, but this form of "autonomy" is often maladaptive. These individuals often exhibit self-absorption and a lack of consideration for their partner's feelings. They tend to disengage quickly from relationships when they feel uncomfortable or perceive the relationship as inappropriate. Therefore, addressing this maladaptive form of autonomy in highly avoidant individuals is crucial for alleviating attachment avoidance. A lack of commitment is a key characteristic of attachment avoidance, as low commitment serves as a means to remain independent and avoid anticipated harm [70]. When partners offer high levels of intangible support, individuals with high attachment avoidance experience similar levels of autonomy to those with low attachment avoidance. Furthermore, stronger goal-related autonomy can help counterbalance the lower commitment typically observed in high-avoidant individuals. Highly avoidant individuals often feel uncomfortable with direct expressions of affection due to their discomfort with intimacy in romantic relationships. Only invisible support, or silent attention from a partner, will prevent highly avoidant individuals from feeling uncomfortable, yet it may also fail to make them feel loved [50]. Attachment avoidance and love addiction are negatively correlated at both Time 1 and Time 2. Individuals with attachment avoidance typically avoid becoming too attached to their partners and tend to disengage quickly from relationships. In contrast, love addicts are more attuned to their partner's needs, considering and caring about their partner's thoughts and feelings. As a result, love addicts generally do not exhibit high levels of avoidance [71].

Conclusion

Love addiction is closely linked to emotional attachment in interpersonal dependence and is negatively associated with avoidant attachment. Attachment avoidance and attachment anxiety are significantly related to autonomy and lack of self-confidence in interpersonal dependence, respectively. By addressing the central symptoms that connect love addiction and insecure attachment patterns, individuals struggling with love addiction and insecure attachment can experience relief and return to a healthier psychological state.

Limitations

This study used online questionnaires and self-report methods for data collection. While this approach is convenient and enables the rapid collection of large-scale samples, self-reporting may introduce social desirability or cognitive biases. Participants may, in an attempt to maintain their self-image, provide responses that align with "socially acceptable" norms or misunderstand certain questions, which could affect the accuracy of their answers. Additionally, participants' evaluations of their emotional states and behaviors might lack objectivity. This study employs network analysis to examine the relationships between love addiction, attachment avoidance, and autonomy. Although network analysis is a powerful tool for revealing dynamic relationships between complex variables, this study does not consider latent variables in the analysis. These efforts contribute to a more comprehensive understanding of love addiction and its underlying psychological mechanisms, offering stronger support for theoretical development and practical interventions. There may be other factors that

contribute to the definition of love addiction, in addition to attachment and dependence. While this paper does not explore these aspects in their entirety, further investigation will be conducted in subsequent studies.

Supplementary Information

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Supplementary Material 1.

Informed consent

Informed consent was obtained from all participants in the study.

Author contributions

GCY conducted the data collection, organized the data, edited the first draft, and translated the article; ZYY and JBN corrected the content as well as the structure of this article; WJY's proofreading of article translations and ZX, ZLQ were responsible for collecting the data.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This research was conducted in accordance with ethical principles, adhering to the guidelines of the relevant institutional review board (IRB) and ethics committees. This study passed the ethical review of the Ethics Committee of the School of Public Health of Dalian Medical University,and adheres to the Declaration of Helsinki.All participants involved in the study provided informed consent, and their confidentiality and anonymity were maintained throughout the research process. The authors confirm that no data was fabricated or falsified, and that all procedures were performed with the utmost respect for participants' rights.
The authors declare that there are no conflicts of interest regarding this study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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