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Examining relationships between psychotic experiences and suicidal ideation in adolescents using a network approach

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ABSTRACT

Background: Suicide is one of the leading causes of death in young individuals. Timely and adequate identification of individuals with suicidal ideation could prevent from suicidal behavior. Psychotic experiences (PE) have been shown to increase levels of suicidal ideation (SI) in the general population. Therefore, detailed investigation of the relationship of PE and SI is relevant. However, the exact nature of the relationship between these two phenomena remains unclear. Understanding psychopathology as a complex network of interacting symptoms could be helpful to elucidate specific associations existing between PE and SI.

Method: A specific type of network analysis, the Ising model, was used to examine connections between dichotomized questions on psychotic experiences and suicidal ideation in a cross-sectional study with 1685 adolescents from the general population aged 13–18 years.

Results: SI was mostly connected to the PE domains perceptual anomalies (PA) and bizarre experiences (BE), which have higher strength values in the network. Central nodes within these domains, as indexed by higher centrality measures (strength and betweenness) were: auditory experiences (PA1: hearing voices when you are alone), persecutory ideation (BE1: feelings of being persecuted; BE2: conspiracy against you), and social anxiety (SANX) (SANX1: I cannot get close to people).

Conclusions: Suicidal ideation is differentially connected to specific psychotic experiences. Auditory PE, persecutory ideation, and social anxiety symptoms could play a central role in the interconnectedness of the two constructs.

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1. Introduction

Suicide represents a major global health burden (Waserman et al., 2005) and one of the major causes of death in young individuals. It has been conceptualized as a continuum of severity, ranging from suicidal ideation, suicide plans, and suicide attempts to completed suicide (Sveticic and De Leo, 2012). However, some authors currently regard suicidal behavior and suicidal ideation as distinct, but correlated phenomena (Klonsky and May, 2015; May and Klonsky, 2016). Suicidal ideation (SI) is highly prevalent in adolescents (Nock et al., 2013), and it is regarded as a predictor of future suicidal attempts and psychiatric crises in this population (Thompson et al., 2012; Czyz and King, 2015). Given the evidence suggesting that suicidal attempts could be prevented by timely and adequately identifying individuals with SI (Panagioti et al.,

2015), a detailed characterization of SI might be helpful to improve the accuracy of early detection of and intervention strategies for suicide in young people (Rueter et al., 2008).

Although numerous risk factors for suicidal behavior have been proposed (Haw et al., 2013; Haw and Hawton, 2015), the knowledge about how these factors interact to increase the risk for actual suicide is scarce (O'Connor and Nock, 2014). Among them, there is nowadays a rising interest regarding the endorsement of psychotic experiences (PE) (Kelleher et al., 2014). PE are prevalent in the general population, with 5.8% of adults (Mc Grath et al., 2015) and 7.5% of adolescents (Ronald et al., 2014; Kelleher et al., 2012) reporting such experiences. In adolescents, PE have been found to co-occur with, among others, victimization and substance abuse (Mackie et al., 2011), use of cannabis (Stefanis et al., 2004), violent behavior (Kinoshita et al., 2011), higher level of emotional stress reactivity (Kline et al., 2014), impaired global functioning (Kelleher et al., 2015), and anxiety and depressive disorders (Sun et al., 2015; Wigman et al., 2012). Additionally, in teenagers, PE not

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only would co-occur with anxiety and depressive symptoms, but probably represent a unitary marker of severity of a single common mental distress (Stochl et al., 2015).

PE have also been found to be related to suicidal ideation (Schimanski et al., 2017), suicide attempt (Kelleher et al., 2013), and deliberate self-harm behavior (Nishida et al., 2010, 2014; Kelleher et al., 2014). Cumulative evidence reveals associations between SI and PE in general samples of adolescents (Kelleher et al., 2012, 2013, 2014), help-seeking adolescents (Nishida et al., 2014), general psychiatric adolescent subjects (Lindgren et al., 2015), young-adults (Capra et al., 2015; De Vylder et al., 2015); and general adults subjects (De Vylder et al., 2015; Koyanagi et al., 2015). Saha et al. (2011) posited delusional-like experiences as a probable marker of vulnerability to suicidal thoughts and behaviors in a sample with a wide range of age, and Capra et al. (2015) observed that perceptual abnormalities and persecutory ideation, but not bizarre experiences, predicted higher suicidal risk in young adults. According to Jang et al. (2014), perceptual disturbances and ideas of reference could be interpreted as warning signs for suicide-related behaviors in general adolescent populations, and visual distortions could explain suicidal ideation in help-seeking adolescents when other psychotic risk symptoms and demographic variables are controlled for (Granö et al., 2015). Finally, auditory hallucinations are associated with both higher rates of suicide attempt (Kelleher et al., 2013) and suicidal ideation (Kelleher et al., 2014), which was also observed in adolescent patients with suicidal ideation (Fujita et al., 2015) and suicidal attempts (Kelleher et al., 2012).

Despite the evidence revealing associations between PE and suicidality (Schimanski et al., 2017), some aspects are controversial. First, the specific nature of the associations between PE and SI and the predictive role of PE on suicidality remain unclear (Sullivan et al., 2015). Some researchers argue that this relationship is artificial (i.e., it could merely reflect a higher underlying risk of suicidal behavior as a function of higher severity of psychiatric symptoms or more severe mental distress) (Honings et al., 2016, 2016a; Jahn et al., 2016), but others posit that the effect is observed even in absence of non-psychotic mental disorders (Bromet et al., 2017; Hielscher et al., 2017). Second, although PE capture multiple symptom domains (e.g. positive PE, negative PE, cognitive PE) (Konings et al., 2006; Stefanis et al., 2002), most research in the context of SI has focused on the association of SI with a limited range of PE, mainly represented by positive PE (i.e., auditory and/or visual hallucinations) (Cederlöf et al., 2017). In this scenario, and given both the high complexity of suicidal ideation and behavior and the fact that its expression has a trans-diagnostic nature, a fruitful approach to gain new insights about its relationships with psychiatric symptoms might be the application of network analysis (de Beurs, 2017; Borsboom, 2017). This approach conceptualizes psychopathology as a system of interacting symptoms, and is able to analyze specific associations between multiple symptoms and reciprocal influences among them (Borsboom and Cramer, 2013; Cramer et al., 2010; Fried et al., 2016a, 2016b; Isvoranu et al., 2017). Thus, it is very well suited to explore a whole system of cognitions, ideas, emotions and behaviors at the same time, which might provide more information than investigating the association between sum scores of PE and SI, for example. As such, it provides specific information on patterns of symptom co-occurrence (Boschloo et al., 2016), generating a visual representation of the complex associations among symptoms (Beard et al., 2016).

Through the application of network analysis, we explored the specific associations between suicidal ideation and individual psychotic experiences encompassing positive, negative and social anxiety experiences in a sample of adolescents from the general population to gain more insights in the way PE and SI are connected. We expected that suicidal ideation would be differentially connected with specific psychotic experiences, and that positive PE would play a more prominent role compared to negative PE in the symptom network of this group of adolescents.

2. Material and methods

2.1. Participants

A cross-sectional study was conducted with 1776 adolescents recruited between April and August 2015 in secondary schools in the city of Talca, Chile. The project was presented to the caregivers during school meetings. All of them authorized the student's participation. Only two students refused to be involved in the study. A total of 91 adolescents did not complete all tests and these participants were removed. We conducted the subsequent analyses in a final sample of 1685 adolescents (mean age = 16.02, SD = 1.46, women = 54.1%).

2.2. Measures

To assess psychotic experiences (PE) we used an item generation deductive method (Hinkin, 1995) of two pre-existing scales that we adapted in previous studies (Núñez et al., 2015, 2016): the Community Assessment of Psychic Experiences—Positive scale (CAPE-P15; Capra et al., 2013), and the Brief Self-report Questionnaire for Screening Putative Pre-psychotic States (BQSPS; Liu et al., 2013). We additionally supported our deductive items proposal by selecting those items that showed stronger factor loadings in the following symptomatic categories (cut-off = 0.50): bizarre experiences (PE1, six items); positive symptoms (PE2, three items); negative psychotic experiences (PE3, three items); and social anxiety (PE4, three items). We adapted the responses categories of the selected items, which now all ranged from 1 (never) to 5 (very often). All assessed items are listed in Table 1 of the Results section. The internal consistency of each subscale (McDonal's ω) is good for the current population (BE = 0.85; PA = 0.86; SA = 0.83; NS = 0.81).

Suicidal ideation (SI) was assessed by six items of the Columbia–Suicide Severity Rating Scale (C-SSRS; Posner et al., 2011), adapted for being used as a self-report questionnaire. Severity of SI was rated on a 6-point ordinal scale in which 1 = wish to be dead, 2 = nonspecific active suicidal thoughts, 3 = thoughts about how to commit suicide, 4 = suicidal thoughts and intentions, 5 = suicidal thought with detailed plan, and 6 = intentions to conduct plan. Frequency of SI was addressed by asking participants when these thoughts happened: ever in life (SI_L) and/or during last month (SI_M). However, we only reported the former because of the small sample size to analyze suicidal ideation during the last month. The internal consistency of each subscale (McDonal's ω) is good for the current population (SI_L = 0.89; SI_M = 0.89).

2.3. Procedure

We translated and adapted the English version of the questionnaires to the Spanish language (Muñiz et al., 2013; International Test Commission, 2006). The items were independently translated by three Spanish speaking psychologists (PhD). These translations were contrasted and discussed, and back-translated by an English native speaking person with knowledge on Spanish language. Given the high agreement obtained during the first translation, no additional changes were conducted. Once written informed consents were obtained from both the caregivers of adolescents and young adults, the participants completed the questionnaires, administered within the classroom setting during school hours by trained psychologists. Ethical approval was obtained from the Bioethics Committee of Universidad de Talca.

2.4. Data analysis

We followed a similar procedure described by Wigman et al. (2016) and estimated an Ising network model for binary data. This model assumes that activation of a node depends on the activation of its

Table 1
Descriptive scores of PE items.

Item	Domain	Mean scores (SD)		Median	%
		Original responses	After recoding		
Have you ever felt that you are being persecuted in anyway?	Bizarre experience (BE1)	1.78 (0.962)	0.20 (0.401)	2	20.1
Have you ever felt as if there is a conspiracy against you?	Bizarre experience (BE2)	1.64 (0.911)	0.14 (0.356)	1	14.9
Have you ever felt that people look at you oddly because of your appearance?	Bizarre experience (BE3)	2.01 (1.085)	0.26 (0.441)	2	26.4
Have you ever felt as if the thoughts in your head are being taken away from you?	Bizarre experience (BE4)	1.69 (0.946)	0.17 (0.382)	1	17.8
Have you ever felt as if the thoughts in your head are not your own?	Bizarre experience (BE5)	1.55 (0.900)	0.12 (0.336)	1	13.0
Have your thoughts ever been so vivid that you were worried other people would hear them?	Bizarre experience (BE6)	1.73 (1.061)	0.19 (0.398)	1	19.8
Have you ever heard voices when you are alone?	Perceptual anomalies (PA1)	1.48 (0.893)	0.11 (0.323)	1	11.9
Have you ever seen objects, People or animals that other people can't see?	Perceptual anomalies (PA2)	1.32 (0.749)	0.07 (0.260)	1	7.3
I feel I cannot get close to people	Social anxiety (SA1)	1.79 (1.033)	0.21 (0.404)	1	20.7
I am mostly quiet when with others	Social anxiety (SA2)	2.14 (1.100)	0.31 (0.463)	2	31.3
I feel nervous when giving a speech in front of a large group of people	Social anxiety (SA3)	2.80 (1.340)	0.53 (0.499)	3	52.7
I cannot focus on a task	Negative symptoms (NS1)	2.70 (1.171)	0.52 (0.500)	3	51.6
I feel mentally insufficient and easily fatigued while thinking or reading	Negative symptoms (NS2)	1.78 (0.995)	0.17 (0.379)	2	17.4
I need to take frequent breaks while working (studying)	Negative symptoms (NS3)	2.69 (1.115)	0.51 (0.499)	3	51.3

neighboring nodes (van Borkulo et al., 2014), and has been previously used to investigate psychopathology (van Borkulo et al., 2014; Boschloo et al., 2015; Boschloo et al., 2016; Wigman et al., 2016). For model estimation, we recoded the responses of questionnaires addressing PE and SI as follows: 0 = “not present” (scores 1–2), 1 = “present” (scores 3–5 for PE, and scores 3–6 for SI). After fitting the Ising model, we analyzed the resulting network using the qgraph package (Epskamp et al., 2012) that visualizes graphs and calculates centrality indices, which provide information on the relative importance of each node in a network. In psychopathology, these measures assess the capability of a symptom to trigger the development of other symptoms (Cramer and Borsboom, 2015). Several types of centrality indices exist. We estimated strength and betweenness. Whereas the former quantifies how well a node is directly connected to other nodes, the latter quantifies how important a node is in the average path between two other nodes (Epskamp et al., 2017).

Thereafter, we estimated the network stability. As recommended by Epskamp et al. (2017), we computed the stability of centrality indices using the correlation stability coefficient (CS-coefficient), which quantifies the maximum proportion of cases that can be dropped to retain, with 95% certainty, a correlation with the original centrality of higher than (by default) 0.7. Values should be at least 0.25 for the centrality to be stable, and preferably above 0.5. Finally, we bootstrapped the 95% confidence intervals of the edge weights, to address if the edges do significantly differ from one-another, which provides an estimate about the accuracy of edges in the networks.

3. Results

Tables 1 and 2 show descriptive scores of PE and SI, respectively, both in raw scores and in dichotomized scores.

Table 2
Percentages of suicidal ideation responses (dichotomized scores, lifetime, last month).

Item	Lifetime		Last month	
	%		%	
	Yes	No	Yes	No
Have you wished you were dead or wished you could go to sleep and not wake up?	47.4	52.6	15.1	84.9
Have you actually had any thoughts about killing yourself?	21.2	78.2	6.4	93.6
Have you thought about how you might do this?	18.3	81.7	5.2	94.8
Have you had any intention of acting on these thoughts of killing yourself	17.0	83.0	5.2	94.8
Have you started to work out or worked out the details of how to kill yourself?	9.4	90.6	3.0	97.0
Do you intend to carry out this plan?	7.8	92.2	2.2	97.8

3.1. Analysis of individual nodes

Fig. 1 shows results of the Ising analysis. These results reveal different patterns of connections of symptoms within each domain of psychotic experiences, and differential connections between these experiences and suicidal ideation. The strongest within-domain inter-connectedness was observed for perceptual anomalies (PA) and bizarre experiences (BE). Within PA, a strong link was observed between visual and auditory experiences (“hearing voices when you are alone” and “seeing objects, people or animals”). Within BE, a strong link was observed between items associated with paranoid ideation (“being persecuted” and “conspiracy against you”). Within the social anxiety domain (SANX), all items are connected each other, but a slightly weaker link was seen between the items “I feel I cannot get close to people” and “nervous when giving a speech in front of a large group”. Within the negative symptom domain (NS), strong connections were observed between “I cannot focus on a task” and both “feeling mentally insufficient and easily fatigued while thinking or reading”.

The visual analysis of connections between different domains of psychotic experiences yielded links between auditory PA and most of BE and also a weak association with one NS (“easily fatigued while thinking or reading”). Moreover, there was a link between the bizarre experience of “people looking at you oddly because of your appearance” and the social anxiety item of “being distant to the people”.

Regarding the links between PE and SI, as depicted in Table 3, the highest strength values were obtained by perceptual (visual) anomalies, social anxiety (feelings of being distant to the people) and auditory psychotic experiences. Additionally, we observed intermediate strength values for items of bizarre experiences (mainly “there is a conspiracy against you” and “people looking at you oddly because of your appearance”). Finally, the connections between SI and negative PE were very weak.

Fig. 1. Representation of network model of psychotic experiences and Suicidal Ideation (life time) items. Two main components are depicted: the symptoms or nodes (circles), and the edges (lines linking the symptoms). The edges represent the relationships between symptoms (green lines correspond to positive associations). The thickness of the edges represents the magnitude of the association between nodes.

3.2. Centrality indices

The structure of the network of symptoms can be described by means of centrality indices, which, based on the analysis of their connectivity patterns, characterize the relative importance of one or several symptoms within the network. One of the most used indicators is degree, which shows the number of nodes connected to a certain node. The strength refers to the sum of the weights of the connections of a particular node (instead of the number of connections). Another index of centrality is betweenness, which refers to the number of shortest pathways between two nodes that a particular node is on, describing the degree to which a node is a connector between other nodes (Costantini et al., 2015; Epskamp et al., 2017).

As shown in Table 4, the mean strength values are quite similar for all domains, but positive PE were slightly higher compared to SANX, negative PE, and SI. At a single node level, the strength centrality analysis reveals that the item addressing perceptual anomalies (“hearing voices when you are alone”) showed the higher value, followed by two items addressing bizarre experiences (“being persecuted” and

“conspiracy against you”) and one item addressing social anxiety (“I cannot get close to people”) (Fig. 2a). Additionally, the betweenness centrality analysis shows large differences among the items. The items with higher values were “I feel I cannot get close to people” (SANX), followed by “there is a conspiracy against you” (BE), and “hearing voices when you are alone” (PA) (Fig. 2b), indicating that these items are often in the shortest pathway between two other symptoms.

3.3. Network stability

The centrality stability analysis yielded the following stability coefficients (CS-coefficients): betweenness: (CS(cor = 0.7) = 0.128); closeness: (CS(cor = 0.7) = 0.205); and strength: (CS(cor = 0.7) = 0.283) (Fig. 3a). The edge-weight accuracy indicated that most edges are not meaningfully different from each other because their confidence intervals overlap (Fig. 3b).

4. Discussion

We examined relationships between several domains of psychotic experiences (i.e. positive PE encompassing perceptual abnormalities as well as bizarre experiences, negative PE and social anxiety) and suicidal ideation in a large sample of non-help-seeking adolescents using network analysis. All domains of experiences were connected, but SI showed stronger connections with the PE domain of perceptual anomalies (PA: “hearing voices”) and social anxiety (SANX: “difficulties to be close to people”). PE with higher strength values in the network were perceptual anomalies (PA) and bizarre experiences (BE: “conspiracy

Table 3
Strength values of connections between SI and PE domains.

Connections	Strength value
SI-BE1	0.21
SI-BE2	0.45
SI-BE3	0.40
SI-BE4	0.09
SI-BE5	0.12
SI-BE6	0.31
Mean	0.26
SI-PA1	0.49
SI-PA2	0.72
Mean	0.61
SI-SA1	0.62
SI-NS1	0.02
SI-NS2	0.08
Mean	0.05

Note: Higher values represent stronger connections.

Table 4
Strength of the 5 subscales (mean, variance, median).

Strength	Mean	Var	Median
Bizarre experiences	4171	0.233	4259
Negative symptoms	3271	0.186	3509
Perceptual anomalies	4249	1523	4249
Social anxiety	3280	1306	3019
Suicidal ideation lifetime	3682	NA	3682

Fig. 2. Strength and betweenness of nodes per subscale.

against you"). These findings suggest that auditory PE, persecutory ideation, and difficulties with social interactions could play a central role in the network as a whole, and that suicidal ideation is differentially connected with specific psychotic experiences. This supports previous research with adolescents and young adults revealing associations between positive PE and suicidal ideation (Kelleher et al., 2014), between SANX and PE (Armando et al., 2013; Michail, 2013), and between SI and SANX (Gallagher et al., 2014).

We have mapped a network of multidimensional subthreshold psychotic experiences organized in clusters with connections within and between PE nodes, and between these nodes and SI. The visual inspection of this network reveals strong connections within each PE cluster and connections between auditory PE and most of the BE nodes. Moreover, we observed that SI was clearly connected to both visual PE and SANX1 (difficulties to be close to people), which was also connected to most of the BE nodes, especially with the feeling of being looked at oddly because one's appearance. The mean of the strength centrality index was relatively similar for each node. Thus, although the auditory PE obtained the highest strength values and despite its multiple connections to other PEs in the network, it is difficult to certainly assert that it has the larger capacity to trigger other PEs and SI. Instead, our results suggest that this capacity might arise from the simultaneous influence of PE nodes with higher centrality indices (i.e., PA (auditory hallucinations); BE (feelings of being persecuted, and being looked oddly by people); and SANX (difficulties to be close to people)). Overall, this

supports the view that psychopathology can be regarded as a network of overlapping symptoms with reciprocal influences among them (Wigman et al., 2016). However, because our cross-sectional design, interpreting these results in causal terms is more a hypothesis than a conclusion.

The SANX experience of having difficulties with being close to people (SANX1) showed the highest value in the betweenness centrality index. This result and the edges visually observed for this node suggests that it might serve as a 'bridge' between the other SANX experiences, BE and SI. Although prior evidence suggests that SANX is associated with psychosis (Birchwood, 2003), and SI in teenagers (Nelson et al., 2002; Valentiner et al., 2002), in subjects at high-risk for developing psychosis (Rietdijk et al., 2013), and individuals with early prodromal symptoms (Cannon et al., 2008), our finding showing a probable "bridging" role of SANX was unexpected. This result fits with evidence suggesting that the explanative contribution of SANX on SI in non-help-seeking adolescents would be incremental with respect to PE. This suggests that including SANX measurements in this population could improve the assessment and prediction of suicide risk, beyond generic PE (Núñez et al., 2016), however, given the lack of evidence based on clinical populations, further research is needed. SANX is frequent in individuals at high-risk for developing psychosis (Johnstone et al., 2005), subjects with early prodromal symptoms (Cannon et al., 2008), first episode schizophrenia patients (Birchwood et al., 2006; Michail and Birchwood, 2009), and patients with established schizophrenia

Fig. 3. A) Average correlations between centrality indices of networks sampled with persons dropped and the original sample. Lines indicate the means and areas indicate the range from the 2:5th quantile to the 97:5th quantile. B) Bootstrapped confidence intervals of estimated edge-weights for the estimated network of PE and suicidal ideation. The red line indicates the edge weight values and the gray area the 95% CIs.

(Huppert and Smith, 2005). It has been mostly related to positive symptoms (Lysaker and Salyers, 2007; Mazeh et al., 2009), particularly to paranoid beliefs (Huppert and Smith, 2005; Lysaker et al., 2010). As we stated, these beliefs seem to play a relevant role in our network structure, and as depicted in Fig. 1, are clearly connected to SANX. Interestingly, the content of the nodes bridging these two domains (SANX1: “I cannot be close to people”; BE3: “people looking me oddly because the appearance”) might lead to feelings of loneliness and social isolation behaviors. According to Michail and Birchwood (2013), in psychosis, social anxiety can be regarded as a psychological reaction to manifestation of the illness and its perceived negative social consequences (fear for stigma, social isolation, loss of social roles, negative identity and self-esteem), which can lead to the development of social anxiety-based self-perceptions or “shame cognitions” (Michail, 2013), which in turn can lead to social avoidance behaviors. This is consistent with literature showing correlations between SANX and some risk factors for suicide: feelings of loneliness in adolescents (Endo et al., 2017; Gallagher et al., 2014; Lasgaard et al., 2011), higher levels of entrapment in a socially anxious psychotic group (Michail and Birchwood, 2013), and higher levels of depression, anxiety and intolerance to uncertainty in patients diagnosed with social anxiety (Armando et al., 2013). Overall, our finding revealing a “bridging role” of SANX is in line with some aspects of the interpersonal theory of suicide (Van Orden et al., 2010), which highlights the thwarted belonging as one of the risk factors for suicidal ideation, as showed by Schimanski et al. (2017) in adolescents with high schizophrenia liability. Further research comprehensively testing this theoretical perspective under the network framework (Borsboom, 2017) could provide useful insights on interactions among suicidal risk factors.

We did not find direct connections between SANX and other positive symptoms (auditory and visual hallucinations). Under the “symptomics” framework (Fried et al., 2016a, 2016b), and including SI into the analysis, some “network based” interpretations can be drawn. As we previously mentioned, auditory PE plays a relevant role in the network. This node is connected to the “paranoid” BE cluster, which is linked to the SANX cluster through the SANX1 node (“difficulties to be close to people”), which in turn is clearly associated to SI. Additionally, visual PE are highly connected to SI, but neither its weaker edges with BE nor its lower betweenness centrality score support a clearly interpretable network of symptoms. Thus, in the light of regular analytic techniques, our results would be consistent with prior evidence of no specific association between SANX and perceptual anomalies in first-episode schizophrenia patients (Birchwood et al., 2007; Michail and Birchwood, 2009; Pallanti et al., 2004; Romm et al., 2012), but inconsistent with significant relationships observed in adult patients with chronic psychosis (Lysaker and Salyers, 2007; Mazeh et al., 2009). These different results might be accounted for by the subthreshold nature of PE in our sample.

Studies examining associations between social anxiety and PE in non-help-seeking population are scant. Overall, our findings are consistent with previous evidence of an association in both teenagers (Nishida et al., 2008) and adults (Mc Grath et al., 2016); however, because the usage of different methods, comparisons with our results should be made with caution. The current study is, to our knowledge, the first to investigate relationships between PE and SI using a network approach. Therefore, there is no previous work to relate to regarding the centrality of SI when analyzed as part of a network of psychotic symptoms. Prior research analyzing depressive symptoms has shown mixed findings with high centrality (Bringmann et al., 2015) and low centrality (Beard et al., 2016; Fried et al., 2016a) of SI. In our study, the strength and betweenness centrality indices of SI were intermediate and low, respectively. Whereas the former suggests that SI is a relevant node within the network, the latter might indicate that SI is specifically connected only to the nodes with highest centrality indices we previously mentioned. It also should be kept in mind that SI might be relatively low in the current sample, as the current analyses pertained to

adolescents from the general population, where SI might be less prevalent than in clinical sample.

Negative PE nodes were not directly connected to SI (only one node was weakly associated with SI). This finding would support a recent meta-analysis revealing no association between negative symptoms and SI (Huang et al., 2017); however, given that both SI and negative PE are connected to the other domains, the associations in the current sample may be more indirect. Because of the restricted content of the items addressing negative PE (mainly focused on mental energy to cope with tasks), our results cannot be directly compared with recent research, which, assessing a broader range of negative symptoms, showed higher suicide risk in schizophrenia patients with prominent negative symptoms related to motivation and pleasure (Jahn et al., 2016), and higher SI in individuals at clinical high-risk for psychosis experiencing greater severity of total negative symptoms (Gill et al., 2015). Given the mixed findings on the associations between negative symptoms and suicidal behavior, and the lack of evidence on the relationships between negative PE and SI, further research using the network approach is needed to elucidate this unclear relationship.

Given the potential advantages of the network analysis to study psychopathology (van Borkulo et al., 2014; Boschloo et al., 2016; Wigman et al., 2016) and suicidal behavior (de Beurs, 2017), its usage can contribute to a better understanding of the nature of the complex relationships between these phenomena, which is intensely debated nowadays. Future network analysis studies should include additional symptom domains to analyze whether the associations between PE and suicidal behavior are undifferentiated (Cederlöf et al., 2017); are specifically and independently associated, regardless of antecedents of mental disorders (Bromet et al., 2017), or if the associations are not specific, but merely reflect a higher underlying risk of suicidal behavior as a function of psychiatric symptoms or mental distress (De Vylder et al., 2015; Honings et al., 2016, 2016a; Sullivan et al., 2015).

Some limitations to the present study deserve mention. First, because the cross-sectional design, we cannot establish causal relationships or identify patterns of symptomatic activation. Second, we addressed PE through items derived from two scales previously adapted in Chilean population. Given that we pooled these items in a single scale, and despite that the reliability, tested by Omega coefficient is good, additional validity studies should be conducted. Third, dichotomized measures can produce larger effects than continuous measures which should be considered when the results are interpreted. Fourth, although our conceptualization of social anxiety was theoretically supported (Keshavan et al., 2011; Liu et al., 2013), we used a limited number of items to address this complex construct, and also to evaluate the negative PE. Fifth, we used data from a general population sample of adolescents with a relatively narrow age range. Further research is needed to disentangle how psychotic experiences and other symptoms are activated each other in both subjects with broader age ranges and clinical samples. For instance, network analysis would be very useful to test the network structure of symptoms belonging to the Acute Suicidal Affective Disturbance (ASAD; Rogers et al., 2017) a new diagnostic entity recently proposed (Tucker et al., 2016). Sixth, we did not address suicide attempts, and therefore, we could not compare suicide ideators and suicide attempters, which is strongly encouraged nowadays (Burke and Alloy, 2015; Klonsky and May, 2014; May and Klonsky, 2016). Moreover, we did not address the distress associated with PE. Therefore, we cannot either draw conclusions on the clinical relevance of PE in our sample or compare this aspect with prior research conducted in other countries (Mc Grath et al., 2016). This is a relevant topic currently debated (Luhmann, 2017) and it should be addressed by future research. Finally, only the CS-coefficient of the strength centrality index was above 0.25, as recommended by Epskamp et al. (2017). Therefore the interpretation of our results should be done with caution. Probably, higher stability coefficients might be obtained in clinical samples, which should be tested in future studies.

In summary, through a network analytic approach, our results add new insights to previous findings concerning the associations between psychotic experiences and suicidal ideation, suggesting that perceptual anomalies (mainly auditory experiences), social anxiety (being distant to people), and bizarre experiences (paranoid beliefs) are connected in a meaningful way to suicidal ideation in a network of symptoms in a sample of non-help-seeking adolescents.

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Contributors

Daniel Nunez designed the study and directed its implementation, did the literature searches, and wrote the manuscript.
Andrés Fresno gave support for the statistical analysis.
Claudia van Borkulo, Philippe Courtet, Victor Arias, and Johanna Wigman reviewed the manuscript and revised critically for intellectual content.
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Conflict of interest

None of the authors have any conflicts of interest.

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