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Reaching reliable change using short, daily, cognitive training exercises delivered on a mobile application: The case of Relationship Obsessive Compulsive Disorder (ROCD) symptoms and cognitions in a subclinical cohort

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ABSTRACT

Background: Relationship Obsessive Compulsive Disorder (ROCD) is a presentation of OCD centering on interpersonal relationships. The aim of this Randomized Control Trial (RCT) was to assess the efficacy of short, game like, daily cognitive interventions delivered via mobile application in reducing subclinical ROCD symptoms and associated phenomena.

Methods: Fifty university students identified as having subclinical levels of ROCD symptoms (using the Structured Clinical Interview for DSM-5 Clinical Version) were randomized into: immediate-use group (iApp group; $n = 25$) and delayed-use group (dApp group; $n = 25$). The iApp group started using the evaluated cognitive-behavioral training application at baseline for 15 days (T0 to T1). The dApp group commenced using the application at T1 for 15 days (T1 to T2). All participants completed questionnaires at baseline (T0), 15 days from baseline (T1), and 30 days from baseline (T2).

Results: Repeated measure MANOVAs showed significant Group (iApp vs. dApp) × Time (T0 vs. T1) interactions. These interactions indicated greater decrease in ROCD symptoms, OCD beliefs and social anxiety symptoms, as well as a greater increase in self-esteem in the iApp group compared to dApp group at T1. Moreover, the Reliable Change Index (RCI) indicated reliable change on ROCD symptoms for a significant portion of participants (42–52%).

Limitations: Sample size and the use of self-report measures limits the generalizability of the results.

Conclusions: Short, daily cognitive training interventions delivered via mobile applications may be useful in reducing subclinical ROCD symptoms and associated features. Further testing is needed for clinical populations.

1. Introduction

Obsessive Compulsive Disorder (OCD) is a disabling disorder with a variety of obsessional themes such as contamination fears, repugnant obsessions, and scrupulosity (Abramowitz and Jacoby, 2014a; 2014b; Moulding et al, 2014; Rachman, 2006). Relationship OCD (ROCD) is a presentation of OCD centering on close interpersonal relationships including romantic and parent-child relationships (Doron et al., 2014a; Levy et al., in press). To date, research has focused on two main forms of ROCD symptoms: relationship-centered and partner-focused ROCD symptoms (Doron et al., 2016; Melli et al., 2018a; Trak and Inozu, 2019).

Relationship-centered ROCD symptoms include doubts and preoccupations focusing on the "rightness" of the relationship (e.g., "Is this the 'right' relationship for me?"), feelings towards one's partner (e.g., "I don't feel passionate about my partner!"), and the feelings of the partner towards oneself (e.g., "Does my partner truly love me?"; Doron et al., 2012a). Partner-focused ROCD symptoms involve disabling preoccupations centering on the perceived flaws of one's relationship partner (Brandes et al., 2020; Doron et al., 2012b). Partner-focused ROCD symptoms include distressing preoccupations with the perceived flawed appearance of the partner (i.e., Body Dysmorphic Disorder by Proxy; Greenberg et al., 2013), however, ROCD symptoms comprise a wider range of perceived flaws including perceived low intelligence, social skills, morality and reliability (Brandes et al., 2020; Doron et al., 2012b).

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ROCD symptoms have been associated with various personal difficulties (e.g., mood, anxiety, other OCD symptoms; Doron et al., 2012a; 2012b) and dyadic distress (e.g., relationship/sexual dissatisfaction and relationship violence; Brandes et al., 2020; Doron et al., 2012a; 2012b; Doron et al., 2014b). For instance, a study comparing ROCD, OCD, and community controls indicated that both clinical groups showed similar levels of interference in functioning, distress, resistance attempts and degree of perceived control (Doron et al., 2016).

ROCD-related intrusive thoughts may include thoughts such as "Is he THE ONE?" or "She is not smart enough", images of the perceived flaw of the partner (e.g., image of the partner's uneven skin) or urges (e.g., the urge to leave one's current partner; Doron and Derby, 2017). Such intrusions often contradict the individual's personal values (e.g., “Appearance is not important to me, so why do I obsess about it”) and/or subjective experiences (e.g., "I know I love her, but I keep questioning my feelings"). ROCD-related intrusive thoughts, therefore, often feel more unacceptable and unwanted, as well as less rational and self-congruent than common worries (Doron et al., 2014a; 2014b).

ROCD symptoms include a variety of compulsive behaviors such as repeated checking and monitoring of internal states, comparisons of one's partner with alternative partners and reassurance seeking (Doron and Derby, 2017). ROCD-related compulsive behaviors may also comprise of visualizing (e.g., being happy together), information seeking (e.g., searching online using terms such as “How I know she is the one”; “What do I do if my partner isn't intelligent enough”), self-reassurance and compulsive interrogation of the partner (Brandes et al., 2020; Doron et al., 2014a; 2014b). Like in other forms of OCD, compulsive behaviors in ROCD are aimed at alleviating the significant distress caused by the unwanted intrusions (Doron et al., 2014a; 2014b).

Cognitive Behavioral Therapy (CBT) including Exposure and Response Prevention (ERP) is considered the first line of treatment for OCD (McKay et al., 2015; National Institute for Clinical Excellence [NICE], 2006). According to CBT models of OCD, individuals with OCD tend to catastrophically interpret commonly occurring intrusive experiences (e.g., intrusive thoughts, images, and urges). Ineffective strategies (e.g., checking, washing, and comparing) used by such individuals to manage distress ensuing from the occurrence or content (i.e., feared outcome) of such intrusions, lead to their escalation into obsessions (Rachman, 1997; 1998).

Several OCD-related maladaptive beliefs have been linked with catastrophic interpretation of intrusive experiences including inflated responsibility, perfectionism, intolerance of uncertainty, over-importance of thoughts and their control, and overestimation of threat (Obsessive Compulsive Cognition Working Group [OCCWG], 1997; 2005). Previous studies have also shown small-medium size associations between OCD-related beliefs and ROCD symptoms (Doron et al., 2016; Doron et al., 2012a; 2012b; Melli, et al., 2018). For instance, findings from a recent study with ROCD patients showed moderate size correlations between ROCD symptoms and OCD-related maladaptive beliefs (Doron et al., 2016). Results from this study also indicated ROCD and OCD patients show small-to-large effect size differences on OCD-related beliefs compared to a non-clinical control group.

Indeed, OCD-related beliefs have been implicated in the maintenance of ROCD symptoms. Intolerance of uncertainty (OCCWG, 2005), for instance, was suggested to increase distress following intrusive doubts and concerns regarding one's feelings towards the partner (e.g., “Do I really love my partner?”). Perfectionism may increase preoccupations with particular features of the romantic partner's personality or appearance (e.g., “She is not intelligent enough”, “His nose is not straight”) and aiming for “just right” experiences (OCCWG, 1997; Summerfeldt, 2004) may lead to extreme preoccupation with the “rightness” of the relationship (e.g., “Is this relationship the right one? Is s/he THE ONE?”). Maladaptive beliefs regarding the importance of thoughts and their control (Clark and Purdon, 1993) may increase the likelihood of suppressing critical thoughts about the partner, thereby increasing their occurrence (Doron and Derby, 2017; Rachman, 1997). Inflated responsibility beliefs may intensify negative emotional responses (e.g., guilt and self-blame) following relationship-related doubts and preoccupations (Doron et al., 2014a; 2014b).

One of the main foci of CBT interventions for all presentations of OCD is to reduce symptoms by challenging and decreasing maladaptive beliefs and associated behaviors (Abramowitz, 2006; Doron and Derby, 2017; Foa, 2010). Indeed, CBT includes diverse strategies for reducing OCD-related beliefs. These include psychoeducation regarding their role in the development and maintenance of OCD, cognitive reconstruction, behavioral experiments and Cognitive Bias Modification (CBM). For instance, ERP exercises, arguably the most research supported element of CBT for OCD (Abramowitz and Jacoby, 2014a; 2014b), disconfirm individual's expected catastrophic outcomes thereby helping reduce adherence to maladaptive beliefs. All these strategies help generate alternative explanations of events, thoughts and emotions, allowing clients to re-assess their unhelpful views and interpretations and to reduce compulsive behaviors (e.g., Abramowitz, 2006; Teachman at al., 2014).

Despite its shown efficacy, many individuals with OCD are unable or unwilling to get CBT treatment for reasons including treatment costs, stigma, and difficulty accessing trained therapists (Marques et al., 2010; O'Neill and Feusner, 2015). Recently, a growing body of literature has suggested that internet-delivered CBT and mobile-delivered CBT applications may increase accessibility and acceptability of CBT treatments (Mahoney et al., 2014; Van Ameringen et al., 2017).

One mobile platform that has shown to reduce psychopathological symptoms and maladaptive beliefs is GGtude (Cerea et al., 2020; Giraldo-O'Meara and Doron, 2020; Pascual-Vera et al., 2018; Roncero et al., 2018; 2019). GGtude has been developed by the author G.D. (Clinical Psychologist and researcher) and Gur Ilany (developer). This platform is designed to challenge maladaptive beliefs using short, touch-screen based interventions. Each session, users are exposed to statements that are consistent or inconsistent with their maladaptive beliefs. They then train to accept statements that challenge their maladaptive beliefs (i.e., inconsistent with such beliefs) by pulling the statements down towards themselves. Users train rejecting statements consistent with their maladaptive beliefs (i.e., throw them upwards, away from themselves; see Section 2.5 for further details).

Several studies have shown that daily use of apps from the GGtude platform during a period of two weeks (3 mins a day) is associated with significant beneficial effects in non-clinical (Giraldo-O'Meara and Doron, 2020; Roncero et al., 2018; 2019) and subclinical samples (Cerea et al., 2020). For instance, a recent Randomized Controlled Trial (RCT) assessed an app from the GGtude platform targeting body image distress (‘GG Body Image’). Results from this RCT indicated that compared with a waitlist control group, training 3 minutes a day for 16 days was associated with reductions in some forms of body dissatisfaction, including BDD symptoms in women at high risk of developing Body Image Disorders (BIDs; Cerea et al., 2020).

Another RCT using an app from the GGtude platform compared “GG relationship doubts” (targeting ROCD symptoms and beliefs) with a waitlist control group. Findings from this study indicated increase in self-esteem and reductions in maladaptive beliefs, ROCD and OCD symptoms for users of the application (Roncero et al., 2019). These effects were maintained during 15 days of follow-up.

Previous studies using the GGtude platform, however, have never evaluated the association between app use and reductions in ROCD symptoms and beliefs using a subclinical ROCD sample (i.e., individuals scoring above clinical threshold on self-report ROCD measures, but not attaining full diagnosis of ROCD using a structured interview; see section 2.5 for more details). Moreover, previous studies have not assessed the reliability of change on measures of ROCD symptoms and beliefs following app use. Reliable change evaluates whether an individual changed significantly more than would be expected given measurement error. Therefore, it specifies the amount of change individuals must

show on a specific psychometric instrument between measurement occasions for that change to be reliable (i.e., larger than that reasonably expected due to measurement error alone). The evaluation of such change provides an understanding of the extent to which change after treatment is reliable (Jacobson and Truax, 1991).

In the current study, participants scoring above the clinical threshold on ROCD symptoms (assessed using self-report measures) were interviewed using the Structured Clinical Interview for DSM-5 Clinical Version (SCID-5-CV; First et al., 2015; 2017) and entered a study aimed at assessing the effect of the "GG Relationship Doubts" (GGRO) application in reducing ROCD beliefs, symptoms, and associated psychological features in university students with ROCD concerns. Reliable change in symptoms and maladaptive beliefs was tested using the Reliable Change Index (RCI; Jacobson and Truax, 1991).

ROCD symptoms were previously associated with increased general distress and lower self-esteem (Doron et al., 2012a; 2012b). We, therefore, examined whether app use would be associated with changes in these variables. Finally, GGRO targets maladaptive beliefs related to relationship anxiety in general (e.g., fear of abandonment, embarrassment, uncertainty and distrust), we therefore also evaluated the associations between app use and social anxiety symptoms.

2. Methods

2.1. Participants

Fifty university students (76% females) aged 20-24 years (M_{age} = 22; *SD* = 1.32) satisfied all the inclusion criteria for the research (see Section 2.4) and were included in the study. Participants were randomized to one of two groups: immediate-use App group (iApp group; n = 25) and delayed-use App group (dApp group; n = 25). As shown in Table 1, groups did not differ in terms of socio-demographic variables, relationship status (single/in a relationship), length of the current romantic relationship (if applicable) and employed self-report questionnaires (see Section 2.3) at baseline (T0).

2.2. Study Design

The study was a RCT with a crossover design (Fig. 1). The iApp group started using GGRO immediately (T0) for 15 consecutive days (until T1). They were then requested to stop using the app until the end of the trial (T2). Participants randomized to the dApp group were requested to start using GGRO at T1 (15 days after the iApp group) and to use the app (crossover) for the following 15 days (T2). Both groups completed self-report questionnaires at T0, T1, and T2. Participants were instructed to complete 3 levels of GGRO a day (approximately 3 min a day).

2.3. Assessment

The socio-demographic information schedule and the SCID-5-CV (First et al., 2015; 2017) were administered at baseline (T0). All other assessments occurred at three time points: baseline (T0), at the end of 15 days (T1), and again after 15 days (T2).

Socio-demographic information schedule: assesses information such as contact information, gender, age, education, relationship status (single/in a relationship), length of the current romantic relationship (if applicable), and self-reported psychological disorders.

Structured Clinical Interview for DSM-5 Clinical Version (SCID-5-CV; First et al., 2015; 2017): interview for the assessment of DSM-5 (American Psychiatric Association [APA], 2013) psychological disorders. For the aim of the study, only modules for OCD and psychotic/schizophrenic disorders were administered.

Relationship Obsessive Compulsive Inventory (ROCI; Doron et al., 2012b; Melli et al., 2018b): 12-item measure assessing relationship-centered ROCD symptoms on a 5-point Likert scale (from 0 = *not at all* to 4 = *extremely*). Three subscale scores (love for the partner, relationship "rightness", and being loved by the partner) as well as a total score can be computed. Examples of items are: "I feel a need to repeatedly check how much I love my partner" and "I constantly doubt my relationship". The Italian version of the ROCI proved to be highly reliable in both non-clinical (αs = .84 to .93) and clinical samples (αs = .81 to .88; Melli et al., 2018b). The ROCI demonstrated high specificity and sensitivity with a cut-off point of 21.5, indicating that individuals who score above 21.5 should be referred for further assessment because they might present relationship-centered ROCD symptoms or may be at risk of developing relationship-centered ROCD (Melli et al., 2018b). For the purposes of the study, we focused only on the total score of the ROCI. In the current study, the total score of the ROCI showed adequate internal consistency values at all the assessment

Table 1
Comparisons between immediate-use App (iApp) group and delayed-use App (dApp) group in sociodemographic variables and outcome measures at baseline.

	iApp group *M* (*SD*)/*n*	dApp group *M* (*SD*)/*n*	$t_{(48)}/\chi^2_{(1)}$	*p*
Gender	6M 19 F	6M 19F		
Age	22.20 (1.26)	21.80 (1.38)	1.07	.29
Education, years	15.52 (1.45)	15.36 (1.50)	.38	.70
Relationship status (in a relationship)	14	11	.72	.40
Length of the romantic relationship, months	28.36 (17.09)	31.73 (24.43)	−.41	.69
ROCI total score	21.08 (8.70)	20.28 (8.69)	.32	.75
PROCSI total score	31.72 (12.70)	30.04 (13.17)	.46	.65
OBQ-46 Perfectionism	31.92 (12.30)	33.80 (12.42)	−.54	.59
OBQ-46 Responsibility for damage	36.16 (12.06)	37.20 (11.06)	−.32	.75
OBQ-46 Control of thoughts	35.24 (12.79)	39.52 (13.18)	−1.16	.25
OBQ-46 Responsibility for omission	16.12 (7.05)	15.92 (5.19)	.11	.91
OBQ-46 Importance of thoughts	15.24 (7.37)	16.32 (6.49)	−.55	.58
OCI-R total score	12.00 (7.57)	17.12 (11.34)	−1.88	.07
NJRE-Q-R total score	17.96 (9.10)	20.04 (9.40)	−.79	.43
IUS-R total score	27.76 (8.07)	29.24 (9.95)	−.58	.57
RSES total score	30.04 (5.53)	30.40 (4.31)	−.26	.80
SIAS total score	22.68 (11.48)	26.24 (13.89)	−.99	.33
DASS-21 total score	18.04 (9.18)	18.44 (12.82)	−.13	.90

Note. iApp = immediate-use App; dApp = delayed-use App; ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE-Q-R = Not Just Right Experiences Questionnaire Revised; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

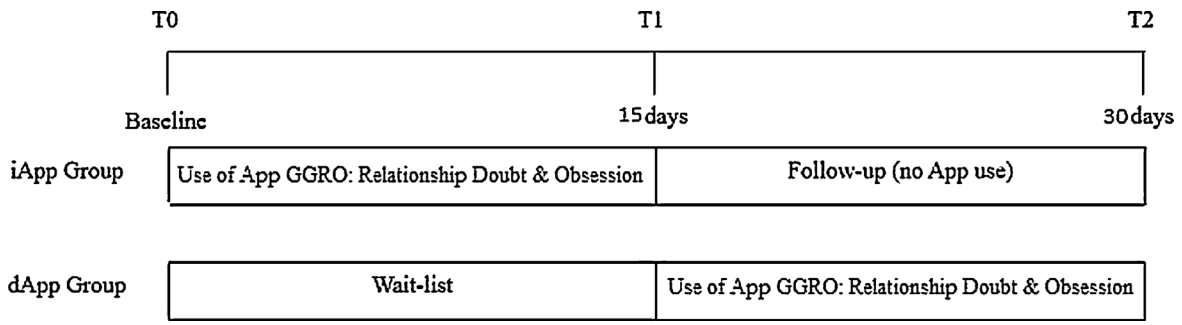

Fig. 1. Study design with both groups.
Note. iApp: immediate-use App; dApp: delayed-use App.

points (Cronbach's *αs* ranging from .83 to .92 in the iApp group and from .84 and .91 in the dApp group).

Partner-Related Obsessive-Compulsive Symptoms Inventory (PROCSI; Doron et al., 2012a; Melli et al., 2018b): 24-item questionnaire assessing partner-focused ROCD symptoms on a 5-point Likert scale (from 0 = *not at all* to 4 = *extremely*). Six subscale scores (physical appearance, sociability, morality, emotional stability, intelligence, and competence) as well as a total score can be computed. Examples of items are: "I repeatedly evaluate my partner's social functioning" (sociability); "I can't stop comparing my partner's intelligence level to that of other men/women" (intelligence). The Italian version of the PROCSI proved to be reliable in both non-clinical (*αs* = .77 to .93) and clinical samples (*αs* = .79 to .94; Melli et al., 2018b). The PROCSI demonstrated high specificity and sensitivity with a cut-off point of 17, indicating that individuals who score above 17 should be referred for further assessment because they might present partner-focused ROCD symptoms or may be at risk of developing partner-focused ROCD (Melli et al., 2018b). For the purposes of the study, we focused only on the total score of the PROCSI. The total score of the PROCSI showed adequate internal consistency values at all the assessment points (Cronbach's *αs* ranging from .86 to .91 in the iApp group and from .84 and .92 in the dApp group).

Obsessive Beliefs Questionnaire-46 (OBQ-46; OCCWG, 2005; Dorz et al., 2009a; 2009b): 46-item measure assessing domains identified by the OCCWG as central to OCD through five subscales: excessive responsibility for omission, excessive responsibility for damage, overimportance of thoughts, excessive control of thoughts, and perfectionism. The Italian version of the OBQ showed good internal consistency values (Cronbach's *αs* ranging from .68 to .86; Dorz et al., 2009a; 2009b). In the current study, internal consistency values for all the subscales of the OBQ-46 emerged to be adequate for both the iApp and the dApp groups at all assessment points (Cronbach's *αs* ranging from .60 to .94 in the iApp group and from .63 and .93 in the dApp group).

Obsessive Compulsive Inventory-Revised (OCI-R; Foa et al., 2002; Sica et al., 2009): 18-item self-report measure assessing OCD symptoms. Participants were asked to rate the degree to which they were bothered by OCD symptoms in the past month on a 5-point Likert scale. The OCI-R assesses OCD symptoms across six factors: washing, checking/doubting, obsessing, mental neutralizing, ordering, and hoarding. The Italian version of OCI-R indicated good internal consistency and test–retest reliability, as well as good convergent, divergent, and criterion validity (Sica et al., 2009). For the purposes of the study, we focused only on the total score of the OCI-R. The total score of the OCI-R showed good internal consistency at all assessment points (Cronbach's *αs* ranging from .70 to .81 in the iApp group and from .82 and .87 in the dApp group).

Not Just Right Experiences Questionnaire Revised (NJRE-Q-R; Coles et al., 2005; Ghisi et al., 2010): 19-item measure assessing Not Just Right Experiences (NJREs). The NJRE-Q-R showed good internal consistency and 30-days test–retest reliability, as well as good convergent and divergent validity (Coles et al., 2003; Ghisi et al., 2010). The NJRE-Q-R showed good internal consistency values in the iApp and dApp groups at all assessment points (Cronbach's *αs* ranging from .85 to .89 in the iApp group and from .88 and .89 in the dApp group).

Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965; Prezza et al., 1997): measure made up of 10 items rated on a 4-point Likert scale assessing global self-esteem. Higher scores represent positive self-esteem. Good internal consistency values have been reported for the RSES, ranging between α = .77 and α = .88 (Dobson et al., 1979; Fleming and Courtney, 1984; Prezza et al., 1997; Robinson et al., 1991). In the current study, the RSES showed adequate internal consistency in the iApp and dApp groups at all assessment points (Cronbach's *αs* ranging from .82 to .86 in the iApp group and from .79 and .87 in the dApp group).

Intolerance of Uncertainty Scale-Revised (IUS-R; Carleton et al., 2007; Bottesi et al., 2019): 12-item self-report questionnaire assessing Intolerance of Uncertainty (IU). Individuals are asked to rate the extent to which each statement applies to themselves on a 5-point Likert scale. The IUS-R has proven to be a reliable and valid measure of IU (Bottesi et al., 2019; Walker et al., 2010). In the current study, the IUS-R showed good internal consistency in the iApp and dApp groups at all assessment points (Cronbach's *αs* ranging from .86 to .90 in the iApp group and from .87 and .91 in the dApp group).

Social Interaction Anxiety Scale (SIAS; Mattick and Clarke, 1998; Sica et al., 2007): a 19-item measure designed to assess social interaction anxiety on a 5-point Likert scale. The original and the Italian version of the SIAS showed strong psychometric properties (Mattick and Clarke, 1998; Sica et al., 2007). In our samples, the SIAS showed good internal consistency (Cronbach's *αs* .87 at all assessments points in the iApp group and *αs*. 92 in the dApp group).

Depression Anxiety Stress Scale-21 (DASS-21; Lovibond and Lovibond, 1995; Bottesi et al., 2015): 21-item measure assessing depression, anxiety, and stress on a 4-point Likert scale. Three subscale scores as well as a total score can be computed (Bottesi et al., 2015). The DASS-21 demonstrated adequate reliability in non-clinical samples (Bottesi et al., 2015; Lovibond and Lovibond, 1995). Findings of the Italian version suggested that the use of the total score (measuring a "general distress" factor) could be more appropriate than calculating the three subscales separately (Bottesi et al., 2015). In accordance, we focused only on the total score of the questionnaire. In the current study, the DASS-21 total scores showed good internal consistency in the iApp and dApp groups at all assessment points (Cronbach's *αs* ranging from .89 to .91 in the iApp group and from .94 and .95 in the dApp group).

2.4. Procedure

Participants were recruited at the School of Psychology, University of Padua. Interested participants gave their informed consent for participation and completed online self-report questionnaires assessing

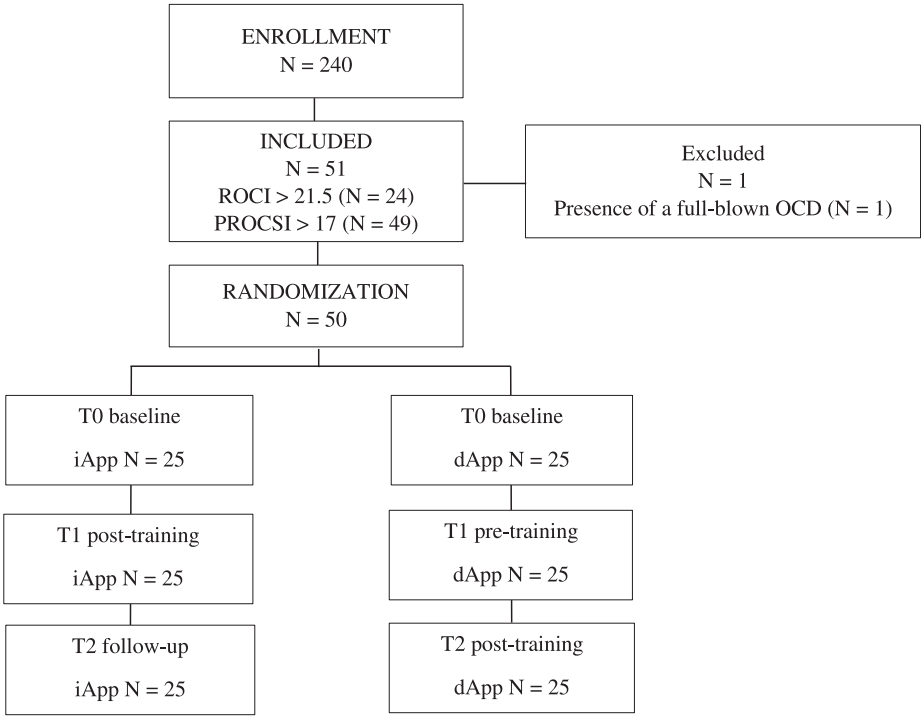

Fig. 2. Flow diagram of participants through the trial.
Note. iApp: immediate-use App; dApp: delayed-use App.

ROCD, OCD beliefs and symptoms, and associated psychological features (Phase 1; see Section 2.3). Participants who satisfied the inclusion criteria of the research (see below) underwent a structured diagnostic clinical interview (Phase 2; SCID-5-CV; First et al., 2015; 2017). Fig. 2 displays the flow diagram of participants through the trial.

Two hundred and forty university students (86.7% females; M_{age} = 21.87; SD = 1.47) completed online self-report measures aimed at assessing Phase 1 inclusion criteria for the research. Participants were eligible if they satisfied the following inclusion criteria: (a) have experienced at least one romantic relationship; (b) presence of ROCD symptoms with values > 21.5 on the ROCI (Doron et al., 2012b; Melli et al., 2018b; see Section 2.3 for details; n = 24 students) or > 17 on the PROCSI (Doron et al., 2012a; Melli et al., 2018b; see Section 2.3 for details; n = 49 students). Fifty-one university students satisfied all of the inclusion criteria of Phase 1 and were contacted by e-mail to take part in the Phase 2 of the research. To assess exclusion criteria (Phase 2), participants underwent to the SCID-5-CV (First et al., 2015; 2017). Exclusion criteria were: (a) presence of a diagnosis of ROCD/OCD (clinical ROCD/OCD as diagnosed by the SCID-5-CV); (b) presence of a psychotic/schizophrenic disorder; (c) current treatment for ROCD/OCD. Based on the exclusion criteria, one participant was excluded (he had a diagnosis of OCD and was receiving CBT treatment). Concerning other self-reported psychological disorders, they were not reported by any of participants.

In total, 50 participants participated in the study (see Section 2.1). They were randomly assigned to either the iApp group or to the dApp group (Phase 3). Block randomization with a fixed block size of two was used to ensure similar sample sizes across conditions. Participants allocated to the iApp group received information about GGRO and were asked to complete 3 levels of the app each day for the duration of 15 days (length of the training with GGRO). With the help of research assistants, participants randomized to the iApp group downloaded the app and were guided through the structure of the app. Students who were randomized to the dApp group had the opportunity to use GGRO at T1 (15 days after the iApp group) and were given the same information as the iApp group.

Participants did not receive any compensation for their participation except for course credits. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical Committee of the Psychological Sciences of the University of Padua.

2.5. Intervention

"GG Relationship Doubts" (GGRO) is an app from the GGtude platform that was developed to challenge dysfunctional beliefs underlying ROCD symptoms and associated psychological features. GGRO was translated into Italian by three of the Italian authors of the paper (S.C., M.G., and G.B.), experts in ROCD and related disorders.

Users go through a tutorial session explaining the impact of self-talk on mood. They are then instructed to reject maladaptive thoughts by throwing them away from themselves (upwards) and to embrace supportive thoughts by pulling them towards themselves (downwards; see Fig. 3). For instance, users of the app are presented with statements such as "Commitment is a trap" or "I can have a successful romantic life". Users are then requested to respond to the former statement by rejecting it (i.e., throwing it upward, away from themselves) and to the latter statement by embracing it (i.e., pulling it downwards, toward themselves). Daily, repeated exposure to statements challenging maladaptive beliefs helps individuals increase accessibility of helpful thinking patterns that facilitate adaptive interpretations of thoughts, emotions, and events associated with ROCD.

On the main page of the app, users are presented a map of 45 levels. They then progressively complete each one of the 45 levels. Every three consecutive levels are dedicated to a specific maladaptive belief associated with ROCD. For instance, the three levels dedicated to intolerance of uncertainty are labeled: "New concept – uncertainty", "Uncertainty" and "Facing uncertainty". Before dealing with a belief such as uncertainty, a screen is presented with the rationale for challenging that belief (e.g., "Fearing uncertainty in relationships perpetuates relationship-related checking and reassurance seeking. Now you will practice tolerating uncertainty").

After completing each level, users receive feedback depending on

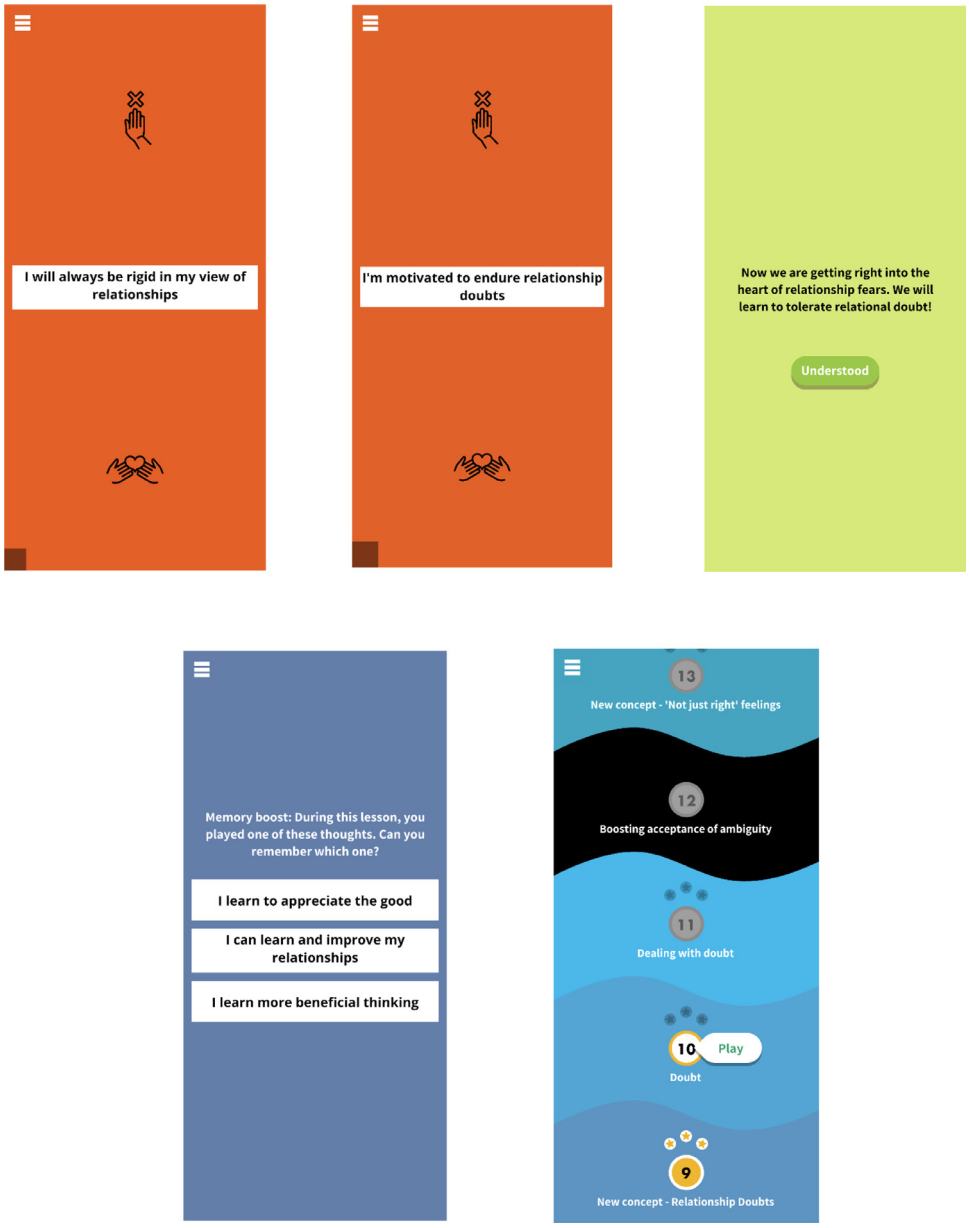

Fig. 3. GGRO: Relationship Doubts screenshots.

the length of time it took them to complete the level (0 to 3 stars are presented on the screen to inform users about the length of time) – the quicker they complete the level the more stars they receive. A short memory quiz (i.e., Memory Boost) follows this feedback. In the Memory Boost game three statements are presented to users, and users have to recall which statement appeared in the level they have just completed. Correct responses result in a "Correct!" message, whereas incorrect responses are followed by a "You'll get it next time" feedback message. These feedback messages increase attention to the training and encourage participants' engagement.

Following the completion of six levels pertaining to two beliefs (e.g., uncertainty and perfectionism), users see encouraging statements such as "Excellent! Now you've learned how to better deal with your feelings of uncertainty and perfectionistic tendencies". Following the completion of three levels each day, a screen prompting users to stop using the app for that day appears. Push notifications remind users to use the app each day and users are advised to train once a day at a preset time rather than in response to distressing thoughts or events. GGRO requires a mobile device with an operating system iOS 7 or above or Android 4.2 or above.

2.6. Statistical analyses

Statistical analyses were conducted using IBM SPSS statistics, version 25. Descriptive statistics were employed to report means, standard deviations, and frequencies. To assess differences between groups on socio-demographic variables and baseline symptoms (T0), Chi-squared (χ^2) and *t*-test analyses were conducted. To investigate correlations between dependent variables at baseline (i.e., scores of self-report questionnaires at T0), Pearson's product-moment correlation coefficients were performed (see Appendix).

Training effects between groups were tested using a 2 × 2 repeated measure Multivariate Analysis of Variance (MANOVA). The MANOVA included the within-subjects factor of Time (T0 vs. T1), the between-subjects factor of Group (iApp group vs. dApp group), and the Group X Time interaction; if one of the main effects (Time, Group) or the Group X Time interaction were significant, we conducted univariate repeated measure follow-up tests to examine the effects separately for each

Table 2
Comparisons across T0 and T1 for iApp and dApp groups.

	T0		T1		Time			Group			Time x Group		
	M (*SD*) iApp group	dApp group	*M* (*SD*) iApp group	dApp group	$F_{(1.48)}$	*p*	ηp^2	$F_{(1.48)}$	*p*	ηp^2	$F_{(1.48)}$	*p*	ηp^2
ROCI total score	21.08 (8.70)	20.28 (8.69)	13.76 (10.56)	19.88 (9.68)	11.93	.001	.20	1.20	.28	-	9.58	.003	.17
PROCSI total score	31.72 (12.70)	30.04 (13.17)	19.48 (14.03)	28.32 (16.91)	19	< .001	.28	.39	.93	-	10.79	.002	.18
OBQ-46 Perfectionism	31.92 (12.30)	33.80 (12.42)	26.08 (10.42)	37.68 (14.75)	.71	.40	-	4.03	.05	.08	17.48	< .001	.27
OBQ-46 Responsibility for Damage	36.16 (12.06)	37.20 (11.06)	28.80 (9.31)	36.52 (11.82)	10.05	.003	.17	2.32	.13	-	6.94	.01	.13
OBQ-46 Responsibility for Omission	16.12 (7.05)	15.92 (5.19)	13.16 (5.84)	17.28 (8.07)	.99	.32	-	1.34	.25	-	7.25	.01	.13
OBQ-46 Control of Thoughts	35.24 (12.79)	39.52 (13.18)	27.64 (10.89)	40.08 (13.60)	6.05	.02	.11	6.49	.01	.12	8.13	.01	.14
OBQ-46 Importance of Thoughts	15.24 (7.37)	16.32 (6.49)	10.88 (3.32)	16.36 (7.16)	7.87	.01	.14	4.17	.05	.08	8.16	.01	.14
OCI-R	12 (7.57)	17.12 (11.34)	6.84 (4.92)	13.96 (8.97)	16.54	< .001	.26	7.86	.01	.14	.96	.33	-
NJRE-Q-R	17.96 (9.10)	20.04 (9.40)	16 (7.75)	19.68 (9.40)	1.35	.25	-	1.54	.22	-	.64	.43	-
IUS-12	27.76 (8.07)	29.24 (9.95)	22.56 (7.63)	27.72 (8.97)	12.61	.001	.21	2.13	.15	-	3.78	.06	-
RSES	30.04 (5.53)	30.40 (4.31)	32.84 (4.87)	29.32 (5.27)	2.89	.10	-	1.24	.24	-	14.71	< .001	.23
SIAS	22.68 (11.48)	26.24 (13.89)	17.04 (10.43)	26.80 (14.60)	5.47	.02	.10	3.77	.06	-	8.14	.01	.14
DASS-21	18.04 (9.18)	18.44 (12.82)	13 (9.35)	18.08 (13.62)	4.97	.03	.09	.84	.36	-	3.73	.06	-

Note. iApp = immediate-use App; dApp = delayed-use App; T0 = pre-training; T1 = post-training; T2 = follow-up; ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE-Q-R = Not Just Right Experiences Questionnaire Revised; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

dependent variable. Then, GGRO effects in the iApp group alone were tested using a 1 × 3 (Time: T0 vs. T1 vs. T2) repeated measure MANOVA. Lastly, a 1 × 3 (Time: T0 vs. T1 vs. T2) repeated measure MANOVA was performed to test changes in the dApp group from T0 to T1 and GGRO effects after the crossover. Pertaining to both analyses, when significant differences emerged, Bonferroni post-hoc comparisons were performed. All participants completed the required self-report questionnaires at T0, T1, and T2 as well as the entire GGRO training; therefore, no missing data emerged. To estimate effect sizes, Partial Eta Squared (η_p^2) indices and Cohen's d values were calculated.

Reliable Change Index (RCI; Jacobson and Truax, 1991) was calculated to assess the reliable change of each participant. The calculation of the RCI requires estimates of a scale's internal consistency and standard deviation for a given population. The threshold for reliable change is calculated as 1.96 times the standard error of the difference between scores of a measure administered on two occasions (pre and post-training). Following Jacobson and Truax (1991) approach, the standard error of measurement (S_E) was first calculated using:

$$S_E = S_1 \sqrt{1 - r_{xx}}$$

(where s_1 = standard deviation at pre-test and r_{xx} = the internal consistency of the measure) and the standard error of the difference score (S_{diff}) derived as:

$$S_{diff} = \sqrt{2\,(S_E)^2}$$

Finally, RCI was calculated:

$$RCI = \frac{X_2 - X_1}{S_{diff}}$$

(where X_2 = individual post-test and X_1 = individual pre-test).

3. Results

3.1. Between group differences (iApp group vs. dApp group)

The repeated measure MANOVA showed a significant Group × Time interaction (F [1, 48] = 2.82, p = .01, η_p^2 = .50) and a significant main effect for time (F [1, 48] = 2.14, p = .04, η_p^2 = .44). Univariate follow-up analyses indicated a significant Group × Time effect for both the ROCI and the PROCSI, on all the OBQ-46 subscales, on the RSES, and on the SIAS. The iApp group showed a greater decrease in scores of all measures compared to the dApp group at T1, with the exception of the RSES that emerged to be higher in the iApp group at T1. Pertaining to the significant main effect for Time, univariate tests indicated that, across groups, both the ROCI and the PROCSI, three of the subscales of the OBQ-46 (responsibility for damage, control of thoughts, and importance of thoughts), the OCI-R, the SIAS, the IUS-R, and the DASS-21 decreased from T0 to T1 in both groups. The main effect for Group was not significant (F [1, 48] = 1.41, p = .20). Results are shown in Table 2.

3.2. Differences between pre-, post-training, and follow-up within the iApp group

Repeated measures MANOVA on all dependent variables revealed a significant effect for Time across all assessments (F [1, 24] = 2.60, p = .001, η_p^2 = .48). Univariate follow-up analyses indicated a significant effect for Time on all of the employed measures. Bonferroni post-hoc comparisons revealed significant reductions from T0 to T1 and from T0 to T2 for both the ROCI and the PROCSI, in all the OBQ-46 subscales, in the OCI-R total score, and in the IUS-R, the SIAS, and the DASS-21 total score. The RSES showed significant increases from T0 to T1 and from T0 to T2, whereas the NJRE-Q-R showed significant reductions only from T0 to T2. No differences emerged from T1 to T2 with respect to all of the employed measures (all ps > .05). Results are shown in Table 3.

3.3. Differences between wait-list condition, pre-, and post-training within the dApp group

Repeated measures MANOVA on all dependent variables revealed a significant effect for Time across all assessments (F [1, 24] = 2.95, p < .001, η_p^2 = .51). Univariate follow-up analyses indicated a significant effect for Time on all of the employed measures with the exception of the IUS-R, the SIAS, and the DASS-21. Bonferroni post-hoc comparisons revealed significant reductions from T1 to T2 and from T0 to T2 for both the ROCI and the PROCSI, in three of the OBQ-46 subscales (responsibility for damage, control of thoughts, and importance of thoughts), and in the OCI-R total score. The responsibility for omission subscale of the OBQ-46 showed significant reductions only from T1 to

Table 3
Comparisons among assessments for the immediate-use App (iApp) group.

	T0 *M* (*SD*)	T1 *M* (*SD*)	T2 *M* (*SD*)	$F_{(1,24)}$	*p*	η_p^2	*Post-hoc*	*Cohen's d*
ROCI Total Score	21.08 (8.70)	13.76 (10.56)	12.32 (9.56)	17.31	< .001	.42	T0 *vs* T1 = *p* = .001	.76
							T0 *vs* T2 = *p* < .001	.96
							T1 *vs* T2 = *p* = .56	.14
PROCSI Total Score	31.72 (12.70)	19.48 (14.03)	18.48 (16.24)	22.64	< .001	.48	T0 *vs* T1 = *p* < .001	.91
							T0 *vs* T2 = *p* < .001	.91
							T1 *vs* T2 = *p* = .99	.06
OBQ-46 Perfectionism	31.92 (12.30)	26.08 (10.42)	24.60 (11.04)	12.18	< .001	.34	T0 *vs* T1 = *p* = .01	.51
							T0 *vs* T2 = *p* < .001	.63
							T1 *vs* T2 = *p* = .99	.14
OBQ-46 Responsibility for Damage	36.16 (12.06)	28.80 (9.31)	24.48 (11.61)	19.60	< .001	.45	T0 *vs* T1 = *p* = .01	.68
							T0 *vs* T2 = *p* < .001	.99
							T1 *vs* T2 = *p* = .05	.41
OBQ-46 Responsibility for Omission	16.12 (7.05)	13.16 (5.84)	11.76 (6.28)	16.63	< .001	.41	T0 *vs* T1 = *p* = .01	.46
							T0 *vs* T2 = *p* < .001	.65
							T1 *vs* T2 = *p* = .13	.23
OBQ-46 Control of Thoughts	35.24 (12.79)	27.64 (10.89)	24.08 (10.98)	13.95	< .001	.37	T0 *vs* T1 = *p* = .01	.64
							T0 *vs* T2 = *p* < .001	.94
							T1 *vs* T2 = *p* = .26	.32
OBQ-46 Importance of Thoughts	15.24 (7.38)	10.88 (3.32)	10.68 (6.57)	10.18	< .001	.30	T0 *vs* T1 = *p* = .01	.76
							T0 *vs* T2 = *p* < .001	.65
							T1 *vs* T2 = *p* = .99	.04
OCI-R Total Score	12.00 (7.57)	6.84 (4.92)	6.40 (5.55)	11.79	< .001	.33	T0 *vs* T1 = *p* = .001	.81
							T0 *vs* T2 = *p* < .001	.84
							T1 *vs* T2 = *p* = .99	.08
NJRE-Q-R Total Score	17.96 (9.10)	16.00 (7.75)	12.32 (6.20)	6.17	.004	.20	T0 *vs* T1 = *p* = .79	.23
							T0 *vs* T2 = *p* = .01	.72
							T1 *vs* T2 = *p* = .05	.53
IUS-R Total Score	27.76 (8.07)	22.56 (7.63)	22.40 (8.76)	15.45	< .001	.39	T0 *vs* T1 = *p* = .001	.66
							T0 *vs* T2 = *p* = .001	.64
							T1 *vs* T2 = *p* = .99	.02
RSES Total Score	30.04 (5.53)	32.84 (4.87)	33.40 (4.87)	15.23	< .001	.39	T0 *vs* T1 = *p* = .003	.54
							T0 *vs* T2 = *p* < .001	.64
							T1 *vs* T2 = *p* = .70	.11
SIAS Total Score	22.68 (11.48)	17.04 (10.43)	18.32 (11.33)	9.35	< .001	.28	T0 *vs* T1 = *p* = .001	.51
							T0 *vs* T2 = *p* = .03	.38
							T1 *vs* T2 = *p* = .88	.12
DASS-21 Total Score	18.04 (9.18)	13.00 (9.35)	12.32 (9.58)	5.94	.005	.20	T0 *vs* T1 = *p* = .04	.54
							T0 *vs* T2 = *p* = .005	.61
							T1 *vs* T2 = *p* = .99	.07

Note. T0 = pre-training; T1 = post-training; T2 = follow-up; ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE-Q-R = Not Just Right Experiences Questionnaire Revised; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

T2, the NJRE-Q-R decreased significantly only from T0 to T2, and the RSES showed significant increases from T1 to T2. A significant reduction from T0 to T1 only emerged with respect to the perfectionism subscale of the OBQ-46, which decreased also from T1 to T2. Results are shown in Table 4.

3.4. Reliable change: Reliable Change Index (RCI)

The RCI specifies the amount of change individuals must show on each self-report questionnaire between measurement occasions for that change to be reliable (i.e., larger than that reasonably expected due to measurement error alone; see Section 2.6 for details). The RCI was calculated for each participant of the iApp group from T0 (pre-training) to T1 (post-training) and for participants of the dApp group from T1 (pre-training) to T2 (post-training). Pertaining to the ROCI and the PROCSI, 40% (iApp group: 13 participants; dApp group: 7 participants) and 52% (iApp group: 18 participants; dApp group: 8 participants) of participants obtained a reliable change from pre- to post-training with GGRO. With respect to the OBQ-46 subscales, 18% of participants obtained a reliable change in the perfectionism subscale (iApp group: 7 participants; dApp group: 3 participants), as well as 14% of participants in the responsibility for damage subscale (iApp group: 4 participants; dApp group: 3 participants), 4% in the responsibility for omission subscale (iApp group: 2 participants), 6% in the control of thoughts subscale (iApp group: 3 participants), and 18% in the importance of thoughts subscale (iApp group: 5 participants; dApp group: 4 participants). Pertaining to the OCI-R total score and the NJRE-Q-R, 32% (iApp group: 10 participants; dApp group: 6 participants) and 10% (iApp group: 2 participants; dApp group: 3 participants) of participants showed a reliable change. Lastly, with respect to the IUS-R, the RSES, the SIAS, and the DASS-21, 10% (iApp group: 4 participants; dApp group: 1 participant), 12% (iApp group: 5 participants; dApp group: 1 participant), 18% (iApp group: 7 participants; dApp group: 2 participants), and 10% (iApp group: 4 participants; dApp group: 1 participant) of participants obtained a reliable change from pre- to post-training. Results are shown in Tables 5 and 6.

4. Discussion

Relationship OCD (ROCD) is a disabling form of OCD focusing on close interpersonal relationships. Although adaptations to existing CBT treatment protocols have been suggested for ROCD (e.g., Doron and Derby, 2017), to date no clinical trials have been published. In this study, we assessed a CBT-based intervention delivered through a mobile

Table 4
Comparisons among assessments for the delayed-use App (dApp) group.

	T0 *M* (*SD*)	T1 *M* (*SD*)	T2 *M* (*SD*)	$F_{(1,24)}$	*p*	η_p^2	*Post-hoc*	*Cohen's d*
ROCI Total Score	20.28 (8.69)	19.88 (9.68)	14.56 (10.43)	11.43	< .001	.32	T0 *vs* T1 = *p* = .99	.04
							T0 *vs* T2 = *p* < .001	.60
							T1 *vs* T2 = *p* = .003	.53
PROCSI Total Score	30.04 (13.17)	28.32 (16.91)	19.36 (15.66)	13.53	< .001	.36	T0 *vs* T1 = *p* = .99	.11
							T0 *vs* T2 = *p* < .001	.74
							T1 *vs* T2 = *p* = .001	.55
OBQ-46 Perfectionism	33.80 (12.42)	37.68 (14.75)	32.28 (14.60)	6.35	.004	.21	T0 *vs* T1 = *p* = .04	.28
							T0 *vs* T2 = *p* = .99	.11
							T1 *vs* T2 = *p* = .002	.37
OBQ-46 Responsibility for Damage	37.20 (11.06)	36.52 (11.82)	30.28 (13.39)	12.31	< .001	.34	T0 *vs* T1 = *p* = .99	.06
							T0 *vs* T2 = *p* = .001	.56
							T1 *vs* T2 = *p* = .001	.49
OBQ-46 Responsibility for Omission	15.92 (5.19)	17.28 (8.07)	13.72 (7.36)	4.97	.01	.17	T0 *vs* T1 = *p* = .95	.20
							T0 *vs* T2 = *p* = .37	.34
							T1 *vs* T2 = *p* < .001	.46
OBQ-46 Control of Thoughts	39.52 (13.18)	40.08 (13.60)	31.56 (13.03)	22.21	< .001	.48	T0 *vs* T1 = *p* = .99	.04
							T0 *vs* T2 = *p* < .001	.61
							T1 *vs* T2 = *p* < .001	.64
OBQ-46 Importance of Thoughts	16.32 (6.49)	16.36 (7.16)	13.04 (6.39)	6.52	.003	.21	T0 *vs* T1 = *p* = .99	.01
							T0 *vs* T2 = *p* = .03	.51
							T1 *vs* T2 = *p* = .02	.49
OCI-R Total Score	17.12 (11.34)	13.96 (8.97)	11.24 (8.87)	9.90	< .001	.29	T0 *vs* T1 = *p* = .18	.31
							T0 *vs* T2 = *p* = .001	.58
							T1 *vs* T2 = *p* = .004	.30
NJRE-Q-R Total Score	20.04 (9.40)	19.68 (9.40)	16.44 (9.91)	5.12	.01	.18	T0 *vs* T1 = *p* = .99	.04
							T0 *vs* T2 = *p* = .04	.37
							T1 *vs* T2 = *p* = .06	.33
IUS-R Total Score	29.24 (9.95)	27.72 (8.97)	26.40 (8.56)	2.37	.11	-	-	-
RSES Total Score	30.40 (4.31)	29.32 (5.27)	31.04 (5.16)	3.47	.04	.13	T0 *vs* T1 = *p* = .36	.22
							T0 *vs* T2 = *p* = .96	.13
							T1 *vs* T2 = *p* = .04	.33
SIAS Total Score	26.24 (13.89)	26.80 (14.60)	24.52 (13.86)	1.01	.37	-	-	-
DASS-21 Total Score	18.44 (12.82)	18.08 (13.62)	15.80 (11.86)	1.43	.25	-	-	-

Note. T0 = pre-training; T1 = post-training; T2 = follow-up; ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE-Q-R = Not Just Right Experiences Questionnaire Revised; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

app specifically targeting ROCD maladaptive beliefs and symptoms in a subclinical ROCD sample.

Consistent with a previous RCT evaluating the same mobile intervention with non-clinical participants (Roncero et al., 2018), our participants with subclinical levels of ROCD symptoms showed medium-large effect size reductions in ROCD symptoms and OCD-related beliefs (as measured by the OBQ-46) and these reductions were maintained at two weeks follow-up. Our findings also indicated reliable change on measures of ROCD symptoms and OCD-beliefs in a significant proportion of participants (40–52% and 4–18% accordingly). Further supporting the effectiveness of the intervention, once our waiting list control group started using GGRO (after crossover), participants in this group showed similar reductions in ROCD symptoms and OCD-related beliefs. Thus, interventions targeting maladaptive beliefs using accessible, cost-efficient, mobile applications may provide an efficient alternative mode of delivery for evidence-based CBT-based programs for OCD.

Replicating and extending the findings of Roncero et al. (2019), training with GGRO have led to a significant increase in self-esteem and to significant reductions in social anxiety symptoms compared to the waitlist control group. The effects obtained on these measures were stable at follow-up and showed reliable changes on the relevant self-esteem and social anxiety measures (12% and 18% accordingly). The improvements made on measures not directly related to ROCD symptoms suggest that targeting maladaptive beliefs associated with ROCD may (directly or indirectly) promote positive self-perception and reduce distress associated with a wider variety of relationships difficulties.

Unexpectedly, no significant interaction effects were found for OCD symptoms (as measured by the OCI-R). A closer look at the iApp group results, however, reveals significant large effect-size reductions on OCD symptoms following the intervention (i.e., between T0 and T1) that was maintained at two-weeks follow-up. Although some reductions in OCD symptoms were found in the dApp group between T0 and T1, these reductions did not reach significance. It seems, therefore, that the lack of interaction effects was a consequence of the reductions in OCD symptoms found in the dApp group. A similar decrease in OCD symptoms without intervention was reported in a previous RCT assessing GGRO (Roncero et al., 2019). The authors of this study suggested that the reduction in OCD symptoms found in their study was related to a decrease in intensity of student requirements/evaluations coinciding with the time period of the study. The fact that our study also comprised of student participants and that our dApp group showed reduction in general distress and intolerance of uncertainty between T0 and T1 is consistent with this proposal.

An alternative explanation for the reduction in OCD symptoms found in the dApp group between T0 and T1 may be that our participants were recruited based on elevated ROCD scores. It is possible that during the two weeks waitlist period of the dApp group, OCD symptoms scores have regressed to the mean. Importantly, however, participants in the dApp group did show significant reduction in OCD symptoms between T1 and T2 (i.e., following crossover). That is, the link hypothesized between app use and reduction in OCD symptoms was found

Table 5
Reliable change = Reliable Change Index (RCI) for the immediate-use App (iApp) group.

	ROCI	PROCSI	OBQ-46 Perfectionism	OBQ-46 Responsibility for Damage	OBQ-46 Responsibility for Omission	OBQ-46 Control of Thoughts	OBQ-46 Importance of Thoughts	OCI-R Total Score	NJRE-Q-R	IUS-12	RSES	SIAS	DASS-21
1	−3,72	−4,16	−2,02	−2,85	−0,80	−2,45	−0,86	−4,33	−0,78	−1,69	1,47	−4.19	−2.14
2	−4,34	−4,58	−2,45	−1,42	−2,01	−1,89	−2,57	−3,51	−0,16	−3,08	0,59	−3.36	−1.76
3	−1,86	−3,96	0,14	−0,12	1,21	0,09	1,07	−0,81	−0,31	−0,77	0,00	−0.42	.88
4	0,00	−2,50	−1,30	0,12	−0,80	−0,57	−0,64	−0,27	0,00	−0,31	−0,88	−.63	.50
5	0,93	−1,04	−1,15	−1,19	0,00	0,85	0,00	0,00	1,57	0,00	1,76	.00	−1.26
6	−2,79	−3,54	0,00	0,00	−0,40	0,66	−0,86	1,08	−0,16	0,00	0,00	−.63	.38
7	−1,86	−0,42	2,16	1,66	0,80	1,70	0,86	−1,08	−0,94	−0,62	0,00	−2.31	1.51
8	−1,55	−3,54	−0,72	−1,78	−0,80	−1,13	−0,86	−0,54	1,88	−0,31	−0,29	−.63	.13
9	−1,24	−3,12	−1,30	-0,59	−2,01	−1,04	−2,14	−2,16	0,00	−0,77	2,35	−.63	.63
10	−5,90	−2,50	0,43	1,19	0,20	0,00	0,21	−1,62	−0,47	−0,77	−0,29	−2.10	−.38
11	−1,86	−5,41	−3,60	−3,20	−2,21	−2,27	−1,28	−2,70	1,25	−0,77	2,06	2.73	−.38
12	0,31	1,25	−0,58	0,59	−0,20	0,94	−0,21	1,35	0,31	0,77	0,29	−.21	1.13
13	−0,93	0,00	0,14	−0,12	0,20	−0,47	0,43	−0,27	−1,88	−0,15	0,88	−.84	−.25
14	−4,65	−3,96	−2,59	−2,26	−1,81	−0,19	−2,14	0,00	1,41	−2,31	0,88	−.89	−1.13
15	−0,93	-4,37	0,29	−0,36	−0,60	−0,57	−0,64	−2,16	−1,41	−0,92	0,88	−2.31	−1.38
16	0,31	−1,25	0,00	−1,07	−1,21	−0,85	0,43	0,00	−0,78	0,00	0,29	.63	−.26
17	−6,21	−4,37	−1,30	−0,83	−0,60	−1,51	−0,21	−3,79	−3,44	−2,62	2,35	−.42	−2.26
18	−4,65	−4,79	0,14	−0,24	0,40	−0,85	−1,28	−3,24	−1,72	−2,16	3,23	−4.40	−2.14
19	−2,48	−2,91	−0,72	−1,42	−0,40	−0,47	−2,57	−3,51	0,78	0,00	2,65	−.84	−.75
20	−2,79	−0,21	−2,74	−1,31	−0,40	−1,42	−0,86	−2,43	0,47	−0,62	−1,18	.63	−2.26
21	1,86	1,46	−0,14	0,24	−0,60	−0,19	−0,21	0,81	1,25	−0,62	0,00	.42	−.38
22	−3,72	−4,16	−0,86	−3,44	−1,41	−1,13	-1,92	0,27	0,00	−0,92	1,18	−.21	−.88
23	−3,10	−5,00	0,58	−1,31	0,20	−0,47	0,43	−4,33	−1,41	0,46	0,88	−.63	−.88
24	−3,72	−4,79	−2,59	−1,31	−1,61	−3,68	−5,35	−1,08	−2,97	−0,77	0,29	−1.89	2.51
25	−9,31	−5,41	−0,86	−0,83	0,00	−1,04	−2,14	−0,54	−0,16	−1,08	1,18	−.42	.25

Note. ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE = Not Just Right Experiences Questionnaire; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

Table 6
Reliable change = Reliable Change Index (RCI) for the delayed-use App (dApp) group.

	ROCI	PROCSI	OBQ-46 Perfectionism	OBQ-46 Responsibility for Damage	OBQ-46 Responsibility for Omission	OBQ-46 Control of Thoughts	OBQ-46 Importance of Thoughts	OCI-R Total Score	NJRE-Q-R	IUS-12	RSES	SIAS	DASS-21
1	−0,25	−1,34	0,13	0,61	−0,51	0,27	0,48	0,00	−0,83	0,16	−0,81	.20	−.59
2	−0,76	−0,50	0,00	−0,61	−0,68	−0,63	−0,72	0,00	1,49	0,80	0,81	−1.39	.00
3	−0,51	−3,00	−2,28	−1,82	−0,51	−2,33	−2,15	−3,00	−0,33	−1,44	0,81	−1.19	−.59
4	0,76	−0,67	−0,51	−2,30	−1,35	−0,99	0,95	−2,67	1,32	−0,80	0,27	−.99	.35
5	−0,76	−2,17	0,13	0,61	−1,01	−0,45	−2,86	0,00	−1,49	−0,16	0,54	−1.19	.00
6	−0,51	−2,34	−0,13	−0,85	−0,68	−0,45	−0,24	0,67	0,00	0,00	0,81	1.98	−2.22
7	−0,51	−1,34	−0,25	−1,21	0,00	−1,79	−1,43	1,00	−1,65	0,16	0,54	−.99	−.12
8	−2,80	−1,50	−0,63	−1,09	−0,51	−0,36	0,48	−1,33	0,33	−0,80	0,27	.79	.47
9	−0,76	−3,17	0,51	−0,48	−0,85	−1,17	0,24	−2,67	−1,65	−1,44	0,54	−.79	−1.76
10	−0,51	−1,84	−1,65	−1,45	−1,01	−0,45	−0,95	−1,33	0,17	−0,80	−0,27	−2.57	−.70
11	0,76	0,83	0,25	−0,12	0,00	0,09	1,43	0,67	0,00	0,32	−1,63	5.15	−1.52
12	0,25	−1,67	−0,89	−0,24	−0,68	−0,72	−1,19	−2,00	0,00	0,00	0,81	−1.19	−.70
13	−3,31	−1,50	−0,51	−1,09	−1,18	−0,81	−0,95	−1,00	−0,50	−0,16	−0,54	−.59	1.87
14	−3,82	−7,34	−2,28	−0,24	−0,68	−0,90	−1,43	−1,67	0,00	1,76	2,98	.59	.59
15	−7,13	−4,67	−0,76	−0,36	0,00	−0,99	0,00	−2,33	0,33	0,32	0,54	−.79	.35
16	−1,53	−0,50	−1,40	−0,97	−0,17	−0,63	0,95	−1,33	0,17	−2,09	0,54	−1.19	1.29
17	0,25	1,50	−1,02	−1,21	−0,85	−1,17	−4,53	−3,00	−0,33	0,32	1,63	−3.57	−1.40
18	0,25	1,00	0,00	−0,97	−1,01	−0,45	0,24	0,67	−2,65	−0,80	0,27	.99	−.35
19	−2,80	−2,00	−0,63	−0,61	−0,68	−1,53	−2,15	−1,33	−2,81	0,16	0,54	−.59	−.94
20	−1,02	0,17	0,38	0,61	−0,17	−0,36	0,00	0,33	0,00	0,48	−0,27	.40	1.05
21	−1,53	−0,67	−2,16	−2,06	0,34	−0,99	−1,91	−0,33	0,00	−0,80	0,81	−1.19	−.70
22	−1,02	−1,17	−0,63	−2,18	−0,85	−1,44	−1,43	−0,33	−1,16	0,00	0,27	.40	.00
23	−2,04	−2,67	−2,28	−1,82	−0,68	0,27	−0,95	0,33	−0,83	0,32	1,63	−1.39	−.23
24	−0,76	−1,00	−0,51	1,21	−0,51	−0,72	0,00	−0,67	−2,32	−0,48	−0,81	−.59	−.59
25	−3,82	0,17	0,00	−0,24	−0,85	−0,45	−1,67	−1,33	−0,66	−0,32	1,35	1.58	−.23

Note. ROCI = Relationship Obsessive Compulsive Inventory; PROCSI = Partner-Relationship Obsessive Compulsive Inventory; OBQ-46 = Obsessional Beliefs Questionnaire – 46; OCI-R = Obsessive Compulsive Inventory – Revised; NJRE = Not Just Right Experiences Questionnaire; IUS-R = Intolerance of Uncertainty Scale – Revised; RSES = Rosenberg Self-Esteem Scale; SIAS = Social Interaction Anxiety Scale; DASS-21 = Depression Anxiety Stress Scale-21.

in the iApp group and then replicated in the dApp group. In fact, 32% of participants showed reliable change on OCD symptoms following intervention.

Replicating previous findings (Roncero et al., 2018; 2019), participants in the iApp group showed reductions in IU beliefs and general distress following GGRO training, and these results were stable at follow-up. Unexpectedly, however, no such declines were found in the dApp group (following cross-over). Nevertheless, 10% of

participants showed a significant pre-post reduction in IU and general distress following training. Future studies would benefit from re-assessing the associations between app use and decreased intolerance of uncertainty and general distress.

Pertaining to the NJREs, no statistically significant results emerged when both groups were compared. However, considering both the iApp and dApp groups, results showed a reduction of NJREs from T0 to T1, with a large effect size. NJREs may be difficult to change with a short-term training; hence, more training levels specifically targeting NJREs may need to be included in GGRO to reduce those feelings, or use of a longer training period in order to have an impact on NJRE feelings. Moreover, GGRO targets maladaptive beliefs, but NJREs are sensory-affective phenomena (Sica et al., 2019): hence, the training provided by the app may have been less effective in improving NJREs since it addresses cognitive (and not sensory) mechanisms. Nevertheless, 10% of participants showed reliable reductions in NJREs after the training with GGRO.

The results of our study replicate previous RCTs showing significant associations between short, daily training challenging maladaptive beliefs and reductions in symptoms (Cerea et al., 2020; Roncero et al., 2019). Extending previous findings, we evaluated levels of reliable change on all assessed measures and included participants with subclinical levels of ROCD symptoms.

Our findings are consistent with CBT models of OCD and ROCD (e.g., Doron et al., 2014a; Rachman, 1998). According to these models, intrusive experiences escalate into obsessions as a result of their catastrophic misinterpretations. Maladaptive beliefs such as the excessive importance attributed to the content or mere occurrence of thoughts, inflated sense of responsibility, perfectionism, and intolerance of uncertainty encourage such catastrophic interpretations. The app used in this study was designed to reduce maladaptive beliefs associated with ROCD symptoms. Daily training exposed users of the app with alternative interpretations of events, thoughts, behaviors, and emotions that are inconsistent with their ROCD-related beliefs. This, together with brief psycho-educational elements, memory quizzes, and daily push-notification reminders, were expected to promote accessibility of such alternative interpretations, thereby, reducing misinterpretations of intrusions and associated ROCD symptoms.

Results of the study suggest that training with an app for 15 consecutive days is effective in reducing ROCD and OCD beliefs, symptoms, and associated psychological features in university students with ROCD concerns. These results are crucial given advantages provided by apps such as wide reach, continuous availability, low costs, and anonymity (Grist et al., 2017; Olff, 2015). Consequently, apps may help in engaging traditionally hard-to-reach groups (Gulliver et al., 2010). Furthermore, these results are in accordance with studies recommending the use of apps for increasing accessibility to mental health treatments (Chandrashekar, 2018; Price et al., 2014) and with the stepped-care approach for OCD, claiming that individuals with OCD may begin with low intensity interventions and, if needed, gradually receive more intense interventions (Gilliam et al., 2010; Tolin et al., 2011).

Despite these promising results, the study has several limitations. First, the sample of this study was relatively small, and participants were recruited from university; hence, the generalizability of our findings is limited. Although we used the SCID assessment of OCD and psychosis/schizophrenia disorders and asked participants to indicate the presence of any current psychological disorders (self-reported), evaluation of commonly comorbid disorders would have been highly relevant to more precise identification of the population that might benefit by the use of the app evaluated in this study. In addition, outcomes in this study were assessed using self-report questionnaires only and the follow-up period was short and available only for the iApp group; future studies should include more objective measures (e.g., clinician reports) and extend the follow-up period, including also a follow-up for the dApp group.

Our control group comprised of participants not using the app. Although unlikely, it may be that mere app use (any app) would lead to such significant reductions in the symptoms assessed in our study. Future studies would benefit from including a more active control group such as an app targeting beliefs that are less relevant to ROCD symptoms (e.g., health anxiety). Comparing face-to-face CBT treatment with and without app use would be another important addition to the literature. We believe that integrating app use with psychological treatment (e.g., following the introduction of maladaptive beliefs) could enhance the effects of face-to-face treatment alone. Using the app following psychological treatment as a response prevention aid may also be beneficial.

5. Conclusions

The current study has shown that short, daily training using a CBT-based app may achieve reliable change in a subclinical sample of ROCD. Therefore, mobile applications may be a promising strategy to increase accessibility of effective CBT-based interventions.

Declaration of Competing Interest

One of the authors of the paper (Guy Doron) is a codeveloper of GGRO. Guy Doron is also a cofounder of GGtude Ltd. GGRO is the subject of this evaluation and therefore has financial interest to GGtude Ltd.

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Supplementary materials

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