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# A preliminary naturalistic clinical case series study of the feasibility and impact of interoceptive exposure for eating disorders

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ABSTRACT

Recent literature suggests that individuals with eating disorders demonstrate altered interoceptive processing, which may relate to the maintenance of symptoms and thus represent a salient treatment target. Adopting treatment techniques effective for other conditions characterized by disturbed interoceptive processes (e.g., anxiety disorders) could aid in improving the outcomes of psychological interventions for eating disorders. The current investigation was a naturalistic case series ($N = 4$) that examined adjunctive interoceptive exposure (IE) for eating disorders, with an emphasis on evaluating the feasibility, acceptability, and impact of this intervention on anxiety sensitivity, interoceptive deficits, and eating disorder symptoms. Results suggested that all individuals who received 4 consecutive sessions of traditional and eating-disorder-specific IE exercises demonstrated decreases in interoceptive deficits and subjective distress. Results for anxiety sensitivity and eating disorder symptoms were encouraging yet more mixed. Findings also generally suggested that the intervention was feasible and acceptable, yet between-session practice compliance varied considerably among participants. Overall, we describe how IE may be used to target interoceptive deficits in eating disorders and provide preliminary evidence of how this may be accomplished within naturalistic intensive outpatient settings.

Eating disorders (EDs) have among the highest mortality and lowest recovery rates of any psychiatric illness (Arcelus, Mitchell, Wales, & Nielsen, 2011; Stice, Marti, & Rohde, 2013) and evidence high comorbidity rates with anxiety and mood disorders (Hudson, Hiripi, Pope, & Kessler, 2007). Treatment approaches such as cognitive-behavioral therapy (CBT) have demonstrated efficacy for EDs, yet there is significant room for improvement (Keel & Brown, 2010). Given evidence of high comorbidity between EDs and anxiety disorders (Kaye et al., 2004), transdiagnostic approaches proven effective for anxiety disorders may also benefit ED intervention efforts.

In the literature on both EDs and fear- and anxiety-related disorders, research findings highlight the role of a general *interoceptive sensitivity* factor (i.e., an individual's ability to correctly detect and monitor interoceptive sensations) that encompasses both eating and digestion specific (e.g., gastric functions) and general autonomic (e.g., cardiac) physiological cues (Herbert, Muth, Pollatos, & Herbert, 2012). This general interoceptive sensitivity factor is closely aligned, empirically and conceptually, with the construct of *anxiety sensitivity,* defined as an individual's tendency to experience anxious states as aversive and dangerous. The combination of both types of sensitivities may increase risk for engagement in eating pathology. For example, an individual with elevated interoceptive sensitivity may go on to develop anorexia nervosa if he or she engages in maladaptive interpretations of weight gain in response to physical cues related to digestion (e.g., fullness). For this individual, certain physical sensations are experienced acutely as strong signals, which become associated over time with a feared outcome (e.g., weight gain). Through interoceptive conditioning, the sensation of fullness becomes associated with anxiety, fear, or other forms of negative affect, as well as body image-related thoughts. With high anxiety sensitivity, the intensity of the emotional experience itself may lead to maladaptive avoidance and emotion-driven behaviors (e.g., restricting, over-exercising), yet both the sensation of fullness (which may be inaccurate due to hypersensitivity) and anxious arousal would separately, or in combination, trigger maladaptive behavioral responses, which are then negatively reinforced. Therefore, both eating/digestion-specific and emotion-based somatic cues represent viable

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targets for transdiagnostic ED treatment, even with individuals who do not present with a comorbid anxiety disorder.

One promising transdiagnostic intervention strategy for this maladaptive conditioning in EDs is interoceptive exposure (IE). IE is a behavior therapy intervention originally developed to treat panic disorder (Barlow, Craske, & Cerny, 1989) by targeting fearful responding and sensitivity toward the physical sensations associated with anxiety and fear (Barlow, Gorman, Shear, & Woods, 2000; Craske, Rowe, Lewin, & Noriega-Dimitri, 1997). IE involves repeatedly inducing these physical sensations (e.g., shortness of breath, heart palpitations, dizziness, muscle tension), with the goal of allowing patients to learn that physical sensations are transient, tolerable, and not harmful, in addition to decreasing their reliance on maladaptive coping strategies (i.e., avoidance, safety signals) (Craske & Barlow, 2007). Craske et al. (2008) demonstrated that this process of inhibitory learning during exposure–where newly learned information prevents previous learning from being expressed– is optimized when patients learn that negative emotions are tolerable and negative expectancies are disconfirmed. IE is also consistent with contemporary perspectives on inhibitory learning, as it emphasizes the identification and labeling of emotions, along with their associated physical sensations (Kircanski, Lieberman, & Craske, 2012). An impaired ability to identify, label, and differentiate between emotions is associated with greater use of maladaptive emotion regulation strategies and increased clinical severity (Herbert, Herbert, & Pollatos, 2011; Mennin, Holaway, Fresco, Moore, & Heimberg, 2007). The specific role of *interoceptive awareness* (identifying and differentiating between somatic and affective cues), or what Merwin, Zucker, Lacy, and Elliott (2010) refer to as *clarity*, is a core element of emotion awareness (Kircanski et al., 2012). Reilly, Anderson, Gorrell, Schaumberg, and Anderson (2017) more recently described the process of inhibitory learning in exposure-based interventions for EDs. As described above, many individuals with EDs evidence impaired interoceptive perceptions (Brown, Smith, & Craighead, 2010; Kaye, Fudge, & Paulus, 2009; Pollatos et al., 2008). Therefore, IE may be a potent intervention strategy through its ability to both improve awareness of and modify sensitivity to physical sensations marked by negative reactivity and non-acceptance of somatic signals and affective response.

The conceptual and empirical scope of IE has expanded in recent years (Boswell, Anderson, & Anderson, 2015; Zvolensky & Otto, 2007). Heightened physiological arousal is a component of many disorders (Barlow, 2002; Naragon-Gainey, 2010), and all emotions have constituent somatic features (Ekman & Davidson, 1994). As such, physiological arousal and distress associated with interoceptive cues represent potential treatment targets for a range of emotion-driven psychopathologies. To date, IE has gathered strong support as an intervention strategy across a spectrum of fear and anxiety-related disorders (e.g., Boswell et al., 2013; Wald, Taylor, Chiri, & Sica, 2010) and may be useful for other conditions, including irritable bowel syndrome (Craske et al., 2011; Hesser, Hedman-Lagerlof, Andersson, Lindfors, & Ljotsson, 2018) and emetophobia (Hunter & Antony, 2009). Individuals with EDs may also benefit from IE, given recent neurobiological models of EDs that implicate interoceptive awareness (Fassino, Piero, Gramaglia, & Abbate-Daga, 2004), interoceptive sensitivity (Pollatos et al., 2008; Zucker et al., 2013), and altered interoceptive processing (Kaye, Wierenga, Bailer, Simmons, & Bischoff-Grethe, 2013) as key vulnerability factors contributing to ED risk and maintenance. Altogether, given evidence of high comorbidity between EDs and mood and anxiety disorders, alongside theoretical work highlighting the potential importance of interoception to ED symptoms, eating/digestion-specific and emotion-focused IE interventions may yield improvement in maladaptive cognitive and emotional responses to physical sensations associated with EDs (Boswell et al., 2015). Overall, current evidence and theory supports a more explicit integration of IE into CBT treatments for diverse EDs.

The transdiagnostic implications of IE led Barlow and colleagues (Barlow et al., 2011, 2017) to incorporate an IE-focused module into a *Unified Protocol* (UP) for transdiagnostic treatment of emotional disorders. The UP model has since been adapted for use in residential and intensive non-residential ED treatment, and this adaptation retains IE strategies (Thompson-Brenner et al., 2018). However, the impact of specific IE strategies on ED symptoms, as well as theoretically-relevant deficits in awareness of and sensitivity to physical sensations, requires further investigation. Further, given data documenting that individuals with EDs may demonstrate alterations in interoceptive sensitivity, endorse elevated anxiety sensitivity, and have problems differentiating between emotional and interoceptive states, individuals with EDs may find engagement in IE particularly aversive. For this reason, additional investigation is also needed to evaluate the acceptability and feasibility of the intervention.

## 1. Current study

The current case series study was conducted within the naturalistic context of a routine intensive outpatient treatment program (IOP) for EDs. Four participants recruited from the IOP received a combination of standard and novel ED-specific IE (described below).[1] The complexities of implementing research in intensive treatment settings for EDs has been documented (Lowe, Bunnell, Neeren, Chernyak, & Greberman, 2011; Thompson-Brenner et al., 2018). It is important to emphasize that this was a clinically-motivated, preliminary investigation of the acceptability and potential usefulness of IE for primary EDs, embedded within a broader, ongoing intensive treatment program. Consequently, all participants were receiving 3–4 times weekly CBT-oriented IOP treatment for EDs that did not include IE as part of the treatment plan. As such, the current study represented a pseudo-additive design, or augmentation, of existing evidence-based treatment for EDs.

Given the novelty of applying this type of intervention in this population, we adopted a case series approach, and our aims were largely exploratory. Participants completed a baseline survey of eating symptoms, anxiety sensitivity, and interoceptive deficits, and then completed a nearly identical version of the battery on multiple occasions. In addition to the survey, participants were asked to practice IE exercises as homework between study sessions. Within-session ratings were recorded during IE trials with a graduate-student facilitator. Based on visual inspection of plotted data, we expected to observe trends of ED symptom improvement, anxiety sensitivity reduction, and decreased interoceptive deficits. We also expected to observe trends of reductions in subjective distress over the course of participants' IE trials.

A core aim of this study was to investigate the acceptability and feasibility of the implementation of IE within standard IOP care. The ED IOP program from which participants were recruited serves individuals with a range of illness severity and primary ED diagnoses (e.g., anorexia nervosa [AN], bulimia nervosa [BN], binge eating disorder [BED]). Patients must be deemed medically cleared for IOP (rather than a higher level of care) and are closely monitored by medical staff. IEs induce abrupt physiological responses, such as increased heart rate through running in place, which can potentially tax medically compromised individuals and even mimic maladaptive compensatory behaviors. Given the nature of IE, questions about suitability for patients with a primary ED have been raised. Consequently, we carefully observed the "tolerability" and feasibility of IE implementation, including examining the level of homework compliance as one potential indicator of acceptability. We also recorded patient reactions to both the

[1] This manuscript focused on four participants who received "traditional" and novel eating disorder-specific interoceptive exposure (IE). However, within the context of a broader investigation, other patient-participants within the same intensive outpatient program (IOP) were randomized to either a control condition (no IE) or alternative IE conditions. Due to recruitment difficulties within this setting and to increase clarity, the present manuscript focused on the "mixed" IE participants.

**Table 1**
Participant demographic information.

| Case | Gender | Ethnicity | Age | BMI | EDDS DSM-5 Diagnosis | Previous Treatment | Anxiety Diagnosis |
|---|---|---|---|---|---|---|---|
| A | Female | White | 20 | 20.08 | OSFED | No | Yes |
| B | Female | White | 24 | 17.89 | AN | Yes | Yes |
| C | Male | White | 54 | 37.49 | OSFED | Yes | No |
| D | Female | White | 58 | 16.48 | AN | Yes | Yes |

*Note*. EDDS = Eating Disorder Diagnostic Scale; AN = anorexia nervosa; OSFED = other specified feeding and eating disorder. All participants received IOP treatment as usual with 4 consecutive interoceptive exposure (IE) sessions that included IE exercises used in traditional practice and IE exercises designed to target theorized eating-disorder-relevant interoceptive cues and related symptoms.

exercises themselves and the overall treatment approach, with the aim of further evaluating the acceptability of this adjunctive intervention.

## 2. Method

### 2.1. Participants

Participants were recruited from routine IOP for EDs. Eligibility for the current study depended upon IOP program eligibility (e.g., medically stable and appropriate for IOP level of care). A total of $N = 4$ patients completed the informed consent process and participated in IE sessions that included both standard IE and ED-specific IE (e.g., exposure hierarchy included both general and ED-specific interoceptive cues). Details for IE sessions are included in the Procedure section. Table 1 lists participant demographics and key clinical characteristics.

The mean age was 39 years ($SD = 19.77$). Across all participants, the average body mass index (BMI) was 22.99 $kg/m^2$; participant body mass ranged from "underweight" to "obese" BMI categories (National Institute of Health, 1998). Specifically, the three female participants had body mass index (BMI) values ranging from 16.48 to 20.08 $kg/m^2$; the male participant had a BMI of 37.49 $kg/m^2$. Based on the Eating Disorder Diagnostic Scale (EDDS; Stice, 2014) revised to reflect diagnostic criteria from the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; American Psychiatric Association, 2013), two participants met criteria for AN, and the other two met criteria for other specified feeding and eating disorder (OSFED). Three participants reported treatment for a mental health problem prior to entering the IOP, yet no participant had prior experience with IE. Three participants reported a history of an anxiety disorder. To maintain confidentiality, participants are labeled as Case A, B, C, or D.

### 2.2. Measures

**Eating Disorder Diagnostic Scale** (EDDS-5; Stice, 2014). The EDDS-5 was used to identify subthreshold and full-threshold ED diagnoses. Based on the original EDDS reflecting DSM-IV-TR ED criteria (Stice, Telch, & Rizvi, 2000), the EDDS-5 is an updated version of the brief, 22-item measure of eating pathology that aims to coincide with DSM-5 diagnostic criteria (APA, 2013). Although no validation studies have yet evaluated psychometric properties of the EDDS-5, psychometric data support the use of the original EDDS for assessing ED pathology, demonstrating good content validity and convergent validity (mean $\kappa = 0.83$), internal consistency ($\alpha = 0.89$), and test-retest reliability ($r = 0.87$) (Krabbenborg et al., 2011; Stice et al., 2000).

**Eating Disorder Examination-Questionnaire** (EDE-Q; Fairburn & Beglin, 2008). The EDE-Q is a self-report assessment of ED symptoms. The EDE-Q asks participants to recall disordered eating attitudes and behaviors from the past 28 days; scores can be used to compute subscales, along with a global score for disordered eating. Psychometric evidence suggests good reliability and validity for this measure (see Berg, Peterson, Frazier, & Crow, 2011 for review), and it has demonstrated strong convergent validity with clinical interview assessment (Black & Wilson, 1996). EDE-Q global scores were used to evaluate overall level of ED symptoms.

**Anxiety Sensitivity Index** (ASI; Reiss, Peterson, Gursky, & McNally, 1986). The ASI was used to measure negative beliefs about the physical sensations, cognitions, and behaviors associated with the experience of anxiety (18 items, scores ranging from 0 to 72; higher scores indicate greater sensitivity). The ASI has been used with a range of disorders (Boswell et al., 2013; Taylor, Koch, & McNally, 1992), and has demonstrated adequate reliability and validity (Vujanovic, Arrindell, Bernstein, Norton, & Zvolensky, 2007). In addition to the ASI total score, we were particularly interested in the Physical subscale score, which assesses distress regarding somatic symptoms.

**Eating Disorders Inventory-3 Interoceptive Deficits Scale** (EDI-ID; Garner, 2004). The EDI-ID subscale of the EDI-3 was used to assess self-reported interoceptive deficits. The EDI-ID subscale asks individuals to rate items, such as "*I don't know what's going on inside me*" and "*I get confused as to whether or not I am hungry*" using a 6-point Likert scale ranging from 0 (*Never*) to 3 (*Always*). The scale has demonstrated good reliability and validity in patients with EDs (Clausen, Rosenvinge, Friborg, & Rokkedal, 2011; Garner, 2004; Wildes, Ringham, & Marcus, 2010), with higher scores indicating greater interoceptive deficits.

### 2.3. Procedure

All procedures were approved by a university institutional review board (IRB). Patients were recruited on a rolling basis from an IOP that operates within a broader group practice setting. Participants were recruited by researchers who were embedded as clinical staff within the IOP, and all study activities took place at the IOP site outside of IOP hours (e.g., before or after IOP, or on non-IOP days). Individuals expressed interest, in person, to study personnel or contacted them directly via phone or email based on a study flyer. Interested individuals attended a baseline assessment appointment, during which participants received detailed information about the study and completed the informed consent process.

Participants first completed a series of self-report measures on a computer via SurveyMonkey. Upon survey completion, the remainder of the first appointment involved a facilitator who provided psychoeducation regarding the nature of emotions, components of emotions, including somatic features, and the rationale for IE. Participants were encouraged to consider IE as adjunctive (i.e., a "bonus") treatment to standard of care, with the premise that although the exercises might feel uncomfortable in the short-term, ultimately this intervention might help to mitigate negative experiences of physical sensations that relate to their ED symptoms. Content for the IE was derived from the published UP manual, with specific ED adaptations based on those suggested by Boswell et al. (2015). Following this baseline appointment, participants met with a research facilitator one time each week for the next 4 weeks. Each session involved a check-in regarding homework, including discussion of homework compliance, as well as a brief review of psychoeducational material. This was followed by facilitator-guided IEs and collection of ratings of symptoms experienced and associated subjective/perceived accompanying distress. IE facilitators were advanced graduate students in clinical psychology completing a practicum placement in the IOP. Each facilitator received didactic and experiential training in IE for diverse disorders, following the approach outlined in the UP manual (Barlow et al., 2011). Facilitators received additional targeted, face-to-face didactic and experiential training in the application of all study-specific IEs.

Each participant first completed a baseline assessment, involving each of the IE tasks listed and described in Table 2, and a related symptom induction assessment. Specific IE exercises were then selected

**Table 2**
Interoceptive exposure exercises.

| Exercise | Duration (seconds) | Procedure | Target Interoceptive Cue/Sensations (and related emotions, symptoms) |
|---|---|---|---|
| Hyperventilation | 60 | Engage in rapid, shallow breathing | Increase rate of breath, shallow breath, tension in chest, dry mouth (feelings of panic, anxiety, fear) |
| Thin straw breathing | 120 | Breathe through narrow straw; pinch straw or increase rate of breathing to elevate intensity | Shortness of breath, increase sense of need for breath, tension in chest (feelings of panic, anxiety, fear) |
| Spinning | 60 | Spin in place; increase speed or close eyes while spinning to elevate intensity | Dizziness, loss of balance, nausea (anxiety, panic, sense of loss of control, detachment) |
| Running in place | 60 | Run or march briskly* in place | Increase rate of breath, increase body temperature, increase heart rate (panic, anxiety, fear) |
| Gulping water until full | 60 | Gulp water rapidly until sensation of fullness induced; focus on sensations for 1 min. | Stomach filling quickly, fullness, bloating, swallowing/tightness in throat (panic, anxiety, disgust, fear of weight gain, urge to reduce fullness) |
| Smelling high calorie food | 60 | Hold cup containing high-fat fast food (french-fries or hash brown) to nose and focus on smell and elicited sensations | Nausea, increase heart rate, increase salivation and taste-related sensory cues (panic, anxiety, disgust, fear of food) |
| Wearing tight cloth | 60 | Wrap broad piece of stretchy fabric around midsection (e.g., area of body that "feels fat") and focus on elicited sensations for 1 min; tighten cloth or attempt to move while wrapped in cloth to increase intensity | Increase awareness of gastric and body-related sensations associated with tight clothes (anxiety, fear, disgust, or worry related to feeling bloated or full, "feeling fat"). |
| Jiggling loose flesh | 60 | Move body in a way that jiggles loose flesh (e.g. around upper arms, stomach, buttocks or thighs) while focusing on sensations | Increase awareness of body-related sensations (anxiety, fear, disgust, or worry related to feeling body parts jiggle, "feeling fat"). |

*Note*. *Participants were instructed to march just briskly enough to elevate their heart rate so as not to reinforce symptomatic exercise/physical activity related behaviors, and given instruction that the goal of the interoceptive exposure practice is to increase heart rate and related cardiac sensations that accompanied the activity. Participants were encouraged to non-judgmentally attend to the induced internal physical sensations.

**Table 3**
Baseline, post-intervention, and follow-up descriptive information across self-report measures.

| Case | Baseline | Final Session | RCI | *d* | Follow-Up | RCI | *d* |
|---|---|---|---|---|---|---|---|
| ASI Total (range 0–72) | | | | | | | |
| A | 13.0 | 13.0 | N | 0.00 | 13.0 | N | 0.00 |
| B | 15.0 | 11.0 | Y | 0.96 | 17.0 | N | −0.48 |
| C | 9.0 | 6.0 | N | 0.72 | 4.0 | Y | 1.20 |
| D | 19.0 | 20.0 | N | −0.24 | 22.0 | N | −0.72 |
| ASI Physical (range 0–24) | | | | | | | |
| A | 6.0 | 2.0 | Y | 1.94 | 2.0 | Y | 1.94 |
| B | 2.0 | 1.0 | N | 0.49 | 2.0 | N | 0.00 |
| C | 3.0 | 0.0 | Y | 1.46 | 0.0 | Y | 1.46 |
| D | 6.0 | 6.0 | N | 0.00 | 6.0 | N | 0.00 |
| Interoceptive Deficits (range 0–30) | | | | | | | |
| A | 15.0 | 2.0 | Y | 3.45 | 2.84 | Y | 3.45 |
| B | 15.0 | 11.0 | N | 1.06 | 15.0 | N | 0.00 |
| C | 6.0 | 5.0 | N | 0.27 | 3.0 | N | 0.80 |
| D | 6.0 | 3.0 | N | 0.80 | 2.0 | N | 1.06 |
| EDE-Q Global Mean (range 0–6) | | | | | | | |
| A | 3.19 | 2.30 | N | 0.67 | 2.30 | N | 0.67 |
| B | 5.01 | 4.64 | N | 0.28 | 4.90 | N | 0.08 |
| C | 2.58 | 1.47 | Y | 0.83 | 1.39 | Y | 0.89 |
| D | 1.89 | 2.38 | N | −0.37 | 2.18 | N | −0.22 |

*Note*. N = No; Y = Yes. *RCI = reliable change index*. ASI = Anxiety Sensitivity Index; EDE-Q = Eating Disorder Examination Questionnaire.

and idiographically applied based on relevance to the participant (i.e., the intensity of distress associated with the exercise and the similarity of the sensations to the participant's typical experience). Between each session, participants were asked to practice IE daily as homework, with a focus on the IE exercise(s) that evoked the most distressing experience. The ED-specific IE strategies were derived from stakeholder feedback, including ED clinicians, patients, and researchers. Following the fourth in-person meeting with IE, participants were asked to complete a 1-month follow-up assessment. This resulted in a total of six measure administrations between baseline and follow-up. As compensation, participants received a $50.00 Amazon.com gift card for completing the baseline appointment, and a $25 gift card after the completion of each exposure session.

The following scores were plotted from the baseline assessment through 1-month follow-up: EDE-Q Global, ASI Total, ASI Physical, and EDI-ID. In addition, within-person effect sizes were calculated between baseline and post-intervention, and baseline and 1-month follow-up. Reliable change indices (RCI) were calculated based on Jacobson and Truax (1991), and applied to post-treatment and follow-up scores using established reliability estimates and baseline standard deviations. We also tracked changes in IE distress ratings, between the baseline appointment and last trial of the final appointment.

## 3. Results

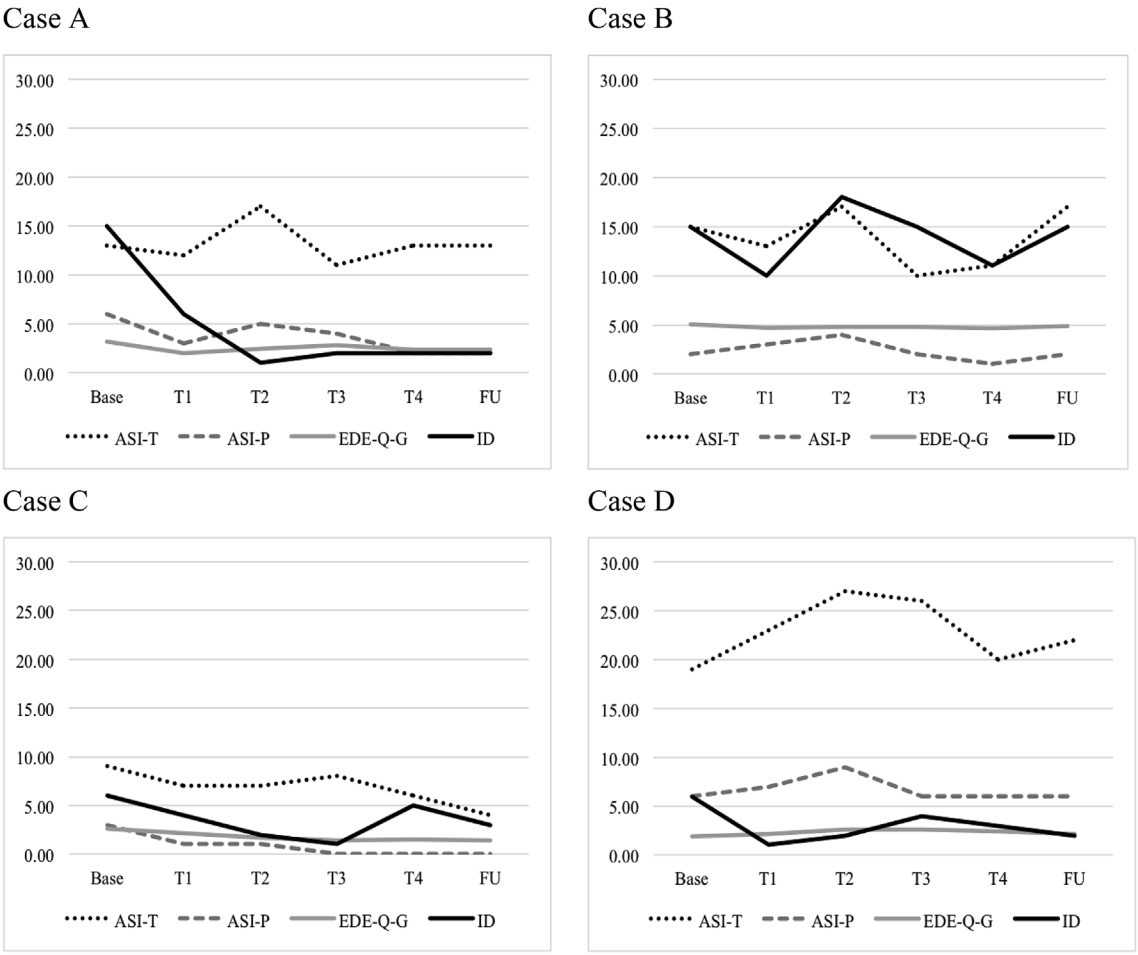
### 3.1. Recruitment

Potential participants in the IOP program were approached in a group format. Recruitment flyers were also posted in waiting areas and group therapy rooms, as well as distributed to treatment staff. A total of 10 IOP patients expressed interested in the study and followed through with the initial screening procedures.[1] Of note, when research staff described the study activities to IOP patients, patients often expressed initial interest in the study. However, relatively few individuals followed through, most often citing scheduling concerns and other responsibilities outside of treatment (e.g., work, school), alongside an already demanding treatment schedule, as reasons for not committing to study participation. For the purposes of this study, four consenting patients received a combination of traditional and more novel eating/digestion-focused exposures (described below).

### 3.2. Case A

Case A evidenced a baseline EDE-Q Global score in the clinically relevant range (Mond, Hay, Rodgers, & Owen, 2006; see Table 3). Scores on the ASI (Taylor et al., 2007) and EDI-ID scales were within the range of normative population scores (Garner, 2004). Compared to baseline, EDE-Q scores improved for Case A ($d$ = 0.67 at both time points), yet these did not meet reliable change criteria on either the EDE-Q or ASI Total ($d$ = 0.00 at both time points). However, reliable change criteria were met for the ASI Physical ($d$ = 1.94) and EDI-ID ($d$ = 3.45) scores at both the post-intervention and one-month follow-up time point.

Fig. 1a includes score plots for the intervention session assessments




*Note.* ASI-T = Anxiety Sensitivity Index Total Score; ASI-P = Anxiety Sensitivity Index Physical Subscale; EDE-Q-G = Eating Disorder Examination-Questionnaire Global; ID = Interoceptive Deficits.

**Fig. 1.** Score plots between baseline (Base) assessment through 1 month follow-up (T1-T4 and FU) for Cases A through D. *Note.* ASI-T = Anxiety Sensitivity Index Total Score; ASI-P = Anxiety Sensitivity Index Physical Subscale; EDE-Q-G = Eating Disorder Examination-Questionnaire Global; ID = Interoceptive Deficits.

for Case A. Percentage of non-overlapping data (PND; Scruggs & Mastropieri, 1998) technically requires a formal baseline period, which we did not have in the present study. However, we borrowed this concept by comparing the IE session and follow-up time points with the baseline score on each variable. Based on this, we observed a lack of overlap with baseline scores on both the ASI Physical and EDI Interoceptive Deficits scales. The most dramatic change was in Interoceptive Deficits between Baseline and Session 2, while eating symptoms appeared to be more contemporaneously associated with ASI Physical scores.

**Interoceptive Exposure Trials.** Table 4 lists the self-report ratings from Case A (as well as the other participants) for each of the baseline symptom inductions. Case A endorsed the highest distress ratings for two ED-specific IEs: wearing a tight cloth and gulping water. When discussing the interoceptive sensations experienced for each IE, this participant reported strong links between IE sensations, negative affect, and eating disorder symptoms (e.g., feeling of fullness was associated with disgust and an urge to purge). Given these links, Case A rated these IE sensations as similar to instances when she engaged in eating disorder behaviors associated with a high degree of negative arousal (e.g., binge eating and purging). The more traditional IE spinning also yielded an intense distress response and high similarity rating, as the participant mentioned that she had long associated feeling dizzy and disoriented with extended periods of caloric restriction, as well as panic and anxiety. Consequently, subsequent IE, including assigned homework, focused on these tasks and symptoms. Fig. 2a plots the last trial distress ratings for Case A across the four intervention appointments. Between the end of the first and fourth appointments, reported distress associated with the cloth decreased from a rating of 5 to a rating of 0. Spinning related distress decreased from 4 to 0, and gulping water decreased from 4 to 2. These results were obtained despite the fact that Case A did not return IE homework documents and, thus, evidenced 0% homework compliance between study appointments (0 days of IE practice rating forms completed and returned to the study therapist). When asked about homework completion during each IE session, this participant informed the study therapist that she intended to practice IE exercises at home, but was often too busy with work and school or did not remember to bring completed homework to each appointment.

### 3.3. Case B

Case B evidenced a baseline EDE-Q Global score in the clinically elevated range (see Table 3). The score on the ASI was above the population average, and EDI-ID scale was within the range of the

**Table 4**
Baseline symptom induction ratings for interoceptive exposures.

| Case | Exercise Type | Intensity | Distress | Similarity | Symptoms Experienced (Based on Participant Reports) |
|---|---|---|---|---|---|
| A | Hyperventilation | 1 | 0 | 3 | More lightheaded towards end, and ability to breathe not as great towards end |
| | Straw | 0 | 0 | 1 | None really since I was able to focus on and control my breath |
| | Spinning | 4 | 2 | 5 | Heart rate dipped up and down … no sense of space, slightly nauseous |
| | Run | 1 | 0 | 1 | Heart rate quicker |
| | Smell | 4 | 0 | 6 | Stomach turning a bit because full when starting trial |
| | Water | 3 | 4 | 6 | Association with purging gets stronger as feeling of fullness heightens |
| | Cloth | 5 | 5 | 5 | "Falling in" feeling of anxiety attack when cloth tightened |
| | Wiggle | 0 | 0 | 0 | None in particular |
| B | Hyperventilation | 7 | 7 | 4 | Light headed, warm, increased heart rate |
| | Straw | 5 | 5 | 5 | Felt like I could not "catch air." tight chest |
| | Spinning | 7 | 8 | 7 | Increased heart rate, warm, nervous, pick at hands |
| | Run | NA | NA | NA | Judged to be ill advised. |
| | Smell | 5 | 7 | 6 | Nauseated, increased heart rate, nervous |
| | Water | 7 | 5 | 5 | Fullness in stomach |
| | Cloth | 3 | 4 | 2 | Generally uncomfortable |
| | Wiggle | 3 | 2 | 3 | Increased heart rate |
| C | Hyperventilation | 6 | 2 | 0 | Dry mouth, out of breath |
| | Straw | 8 | 8 | 8 | Sweating, fast heartbeat |
| | Spinning | 7 | 1 | 8 | Dizzy, sweating, wobbly, disoriented, short of breath |
| | Run | 6 | 2 | 8 | Out of breath, sweaty |
| | Smell | 5 | 0 | 8 | Ears ringing, sweating, salivation |
| | Water | 5 | 5 | 8 | Nauseous, gassy, tight waistband, feel water going down |
| | Cloth | 4 | 3 | 2 | Full stomach |
| | Wiggle | 4 | 4 | 8 | Sweating, short of breath |
| D | Hyperventilation | 2 | 1 | 1 | Wish it was done |
| | Straw | 6 | 6 | 5 | Uncomfortable, shortness of breath, boxed in, panic/concern |
| | Spinning | 7 | 5 | 3 | Dizzy, uncomfortable, out of control when eyes closed, just want to be done |
| | Run | 2 | 0 | 0 | Liked it, increased heart rate/breathing |
| | Smell | 0 | 0 | 0 | Smell, memory of annoying smell/imitation |
| | Water | 7 | 7 | 7 | Uncomfortable, full, not good, overly stuffed, queasy, disliked it, anxious |
| | Cloth | 5 | 5 | 6 | Uncomfortable, constricting, pressure, memories of inpatient and being re-fed, anxious |
| | Wiggle | 2 | 2 | 2 | Glad to be moving, hard to visualize loose flesh, brought back memories of being overweight, anxiety about regaining weight |

*Note.* Ratings based on scale ranging from 0 = "Not at all" to 8 = "Extremely.

normative population scores. Compared to baseline, EDE-Q scores somewhat improved for Case B at end of IE treatment and 1-month follow-up ($d = 0.28$ and $d = 0.08$, respectively), yet these did not meet reliable change criteria on the EDE-Q, ASI Physical score ($d = 0.49$; $d = 0.00$), or EDI-ID ($d = 1.06$; $d = 0.00$). Reliable change criteria were met for the ASI Total at the post-intervention time point ($d = 0.96$), but not at one-month follow-up ($d = -0.48$) where a notable relapse of symptoms in this domain was observed.

Fig. 1b includes score plots for the intervention session assessments for Case B. Visual inspection of scores over time demonstrates that ASI Physical and EDE-Q scores remained relatively consistent with baseline levels throughout the intervention period and follow-up. A higher degree of variability was observed in Interoceptive Deficits and ASI Total scores over time, and relative increases and decreases between these scores appeared to map onto one another at most time points. When considered alongside reliable change indices associated with each variable (see Table 3), patterns in symptom scores suggest that IE was associated with improvements in Interoceptive Deficits and ASI Total scores through the final session of IE; however, this change was only noticeable for ASI Total scores, and did not appear to last through 1-month follow up. Moreover, examination of the plotted scores suggests that symptom improvement was not consistent across weeks, as Case B demonstrated decreases in Interoceptive Deficits and ASI Total scores at T1 and T3, but increases at T2.

**Interoceptive Exposure Trials.** Table 4 lists the self-report ratings from Case B for each of the baseline symptom inductions. Case B endorsed relatively high distress ratings for multiple IEs. Based on distress and similarity ratings, the participant and facilitator agreed to focus on smelling high calorie food, spinning, and straw breathing. While completing the baseline assessment of interoceptive sensations, the participant reported that she felt her throat tighten, stomach clench, and anxiety rise in response to smelling the high calorie food item, as it was a food that she associated with purging episodes. As an individual with a history of panic attacks and a comorbid anxiety disorder, this participant also reported that she associated spinning and straw breathing with acute panic sensations and, thus, rated them as particularly aversive IEs. Based on initial discussions with the participant regarding IE, its function, and the focus of the activity, it was determined that the running IE activity would be ill advised for this participant, as it had the potential to reinforce problematic exercise behaviors in this particular case. Fig. 2b plots the session-by-session end distress ratings for Case B. Distress regarding the smelling of food decreased from a rating of 7 to 1; spinning decreased from a rating of 8 to 1; and straw breathing decreased from a rating of 5 to 2. Similar to Case A, recorded homework compliance was quite low (7%). However, compliance was rated in returned homework forms, and it is important to note that this participant reported completing daily IEs, yet failed to return the homework forms at most of her IE sessions. At the completion of her study participation, this participant informed the study therapist that she was working with her individual therapist to continue her IE work, which included pairing newly-identified IEs with situational exposures (e.g., going into public locations when she felt full and bloated after eating).

### 3.4. Case C

Case C evidenced a baseline EDE-Q Global score in the clinically relevant range (see Table 3). Scores on the ASI and EDI-ID scales were

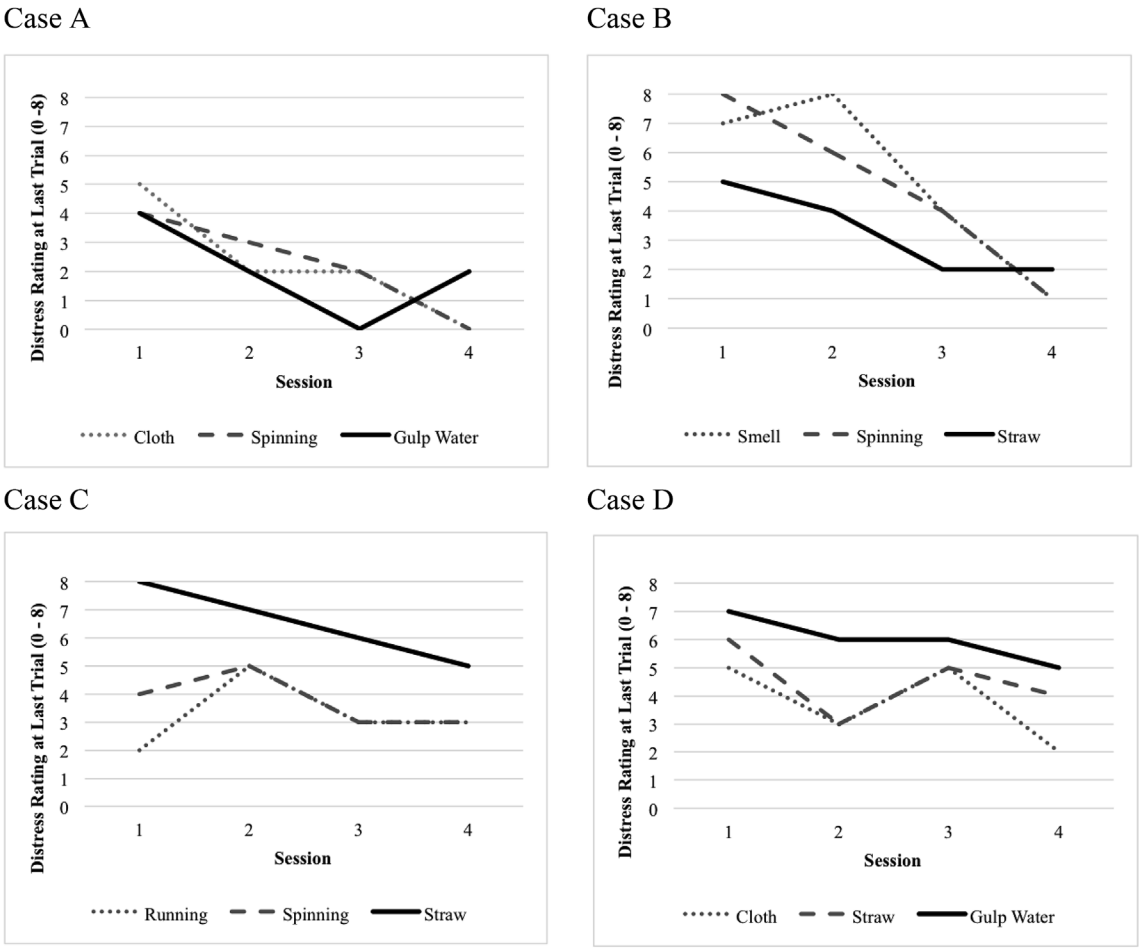



**Fig. 2.** Maximum distress ratings reported for each in-session interoceptive exposure exercise for Cases A-D.

within the range of the normative population scores. Compared to baseline, EDE-Q scores improved for Case C ($d$ = 0.83 and $d$ = 0.89, respectively), and this participant ended in the subclinical range. Further, reliable change criteria were met at both time points. Reliable change criteria were also meet on the ASI Physical score at both time points ($d$ = 1.46; $d$ = 1.46, respectively), and the ASI Total score at one-month follow-up ($d$ = 1.20; post-intervention, $d$ = 0.72). Although improvements in Interoceptive Deficits were observed, these changes did not meet reliable change criteria at either time point (post-intervention, $d$ = 0.27; follow-up, $d$ = 0.80).

Fig. 1c includes score plots for the intervention session assessments for Case C. Visual examination of the score plots demonstrates that no observed scores over the intervention or follow-up period exceeded the respective baseline time point score. Further, there appeared to be improvements on all indicators between Baseline and the Session 2, with a pattern of some variability in ASI Total and Interoceptive Deficits scores from that point forward (e.g., different trends are evident across symptom scores plotted from T2 through follow up in Fig. 1b). Similar to Case A, the steepest improvement was observed in the domain of Interoceptive Deficits. Although there was an abrupt "reversal" between Sessions 3 and 4, this did not coincide with similar deteriorations in eating symptoms or anxiety sensitivity. When considered alongside reliable change indices associated with each variable (Table 3), patterns in symptom scores suggest that IE was associated with improvements in EDE-Q, ASI Physical, and ASI Total scores from baseline through 1-month follow up.

**Interoceptive Exposure Trials.** Table 4 lists the self-report ratings from Case C for each of the baseline symptom inductions. Case C endorsed a range of distress ratings across the IEs. Based on distress and similarity ratings, the participant and facilitator agreed to focus on straw breathing and running in place – which reportedly evoked symptoms like those experienced before and during a binge episode – as well as spinning. This participant had a prior history of alcohol abuse, and stated the symptoms evoked by spinning caused anxiety because they were so similar to how the individual used to feel while drunk. Fig. 2c plots the session-by-session end distress ratings for Case C. Distress related to straw breathing decreased from a rating of 8 to 5; however, little movement was observed for running or spinning – likely because these exercises evoked less intense distress from the start. Homework compliance for Case C was 33.3%. Although the participant reported high motivation, he described external factors such as time constraints as barriers to practicing the exercise between sessions.

### 3.5. Case D

Case D was the only participant to evidence a baseline EDE-Q Global score in the normal range (see Table 3). The score on the ASI was above the nonclinical population average and EDI-ID scale was within the range of the normative population scores. Compared to baseline, EDE-Q scores increased at both post-intervention ($d$ = −0.37) and one-month follow-up ($d$ = −0.22) time points; similar results were observed on the ASI Total ($d$ = −0.24; $d$ = −0.72). In addition, no changes were observed on the ASI Physical scale at either time point ($ds$ = 0.00). It is important to note that these scores did not meet criteria for a reliable deterioration. In contrast, improvements in Interoceptive Deficits were observed at post-intervention ($d$ = 0.80) and one-month follow-up ($d$ = 1.06), yet these changes did not meet reliable change criteria.

Fig. 1d includes score plots for the intervention session assessments

for Case D. Visual inspection of score plots for Case D suggests that, with the exception of Interoceptive Deficits, indicator scores remained relatively consistent with the baseline level. However, a steady increase in the Anxiety Sensitivity Total was observed between Baseline and Session 2. Although not surprising, there appeared to be a relationship between contemporaneous ASI Total and ASI Physical scores, such that increases or decreases in scores from one time point to the next in ASI Total scores coincided with similar changes in ASI Physical scores (interestingly, such trends were not consistently observed in the other cases). For example, when examining Fig. 1d, it is evident that after the Baseline assessment, EDE-Q and Interoceptive Deficits scores appeared to track one another between Session 1 and one-month follow-up.

**Interoceptive Exposure Trials.** Table 4 lists the self-report ratings from Case D for each of the baseline symptom inductions. Case D endorsed the highest distress ratings for wearing cloth and drinking water, and the reported sensations (e.g., feeling of full and queasy, uncomfortable pressure) were rated as similar to instances when the participant engages in (or is about to engage in) problematic eating behaviors and has a high degree of negative arousal. In particular, this participant reported that these exercises evoked memories of being refed during inpatient treatment, and her emotional responses had elements of disgust in addition to anxiety. The more traditional IE straw breathing also yielded an intense response and high similarity rating. Consequently, subsequent IE, including assigned homework, focused on these tasks and symptoms. Fig. 2d plots the maximum distress ratings for Case D across the four intervention appointments. Between the initial trial of the first session, reported distress associated with the cloth decreased from a rating of 5 to a rating of 2. Gulping water related distress ratings decreased from 7 to 5. Straw breathing distress decreased from 6 to 4. Case D evidenced 100% compliance with assigned homework. This participant expressed an appreciation for the physiological ("scientific") rationale for IE. At the final session, this participant stated that she found the IE interesting and useful, and told the facilitator that she intended to continue the work with her individual therapist.

## 4. Discussion

This preliminary case series study provides an initial test of feasibility and acceptability of IE for EDs, administered as a 4-session adjunct to traditional CBT delivered within an intensive-outpatient program (IOP). Additionally, the current investigation explored the potential usefulness of this intervention for targeting anxiety sensitivity, ED symptoms, and interoceptive deficits among individuals with varying EDs. Results suggested that participants demonstrated decreases in interoceptive deficits and subjective distress. Results for anxiety sensitivity and eating disorder symptoms were encouraging yet more mixed. Findings also generally suggested that the intervention was feasible and acceptable, yet between-session practice compliance varied considerably among participants. There are no significant safety-related concerns regarding administration of the intervention, and half of participants chose to continue with the IE intervention following the 4-session study completion, supporting its feasibility and acceptability. However, it is important to note that recruitment and homework completion rates were relatively low and, therefore, may present challenges for dissemination and implementation of adjunct IE modules in similar IOP-level settings. In regards to the benefits of the intervention, 3 out of 4 participants evidenced positive changes on self-report indicators of ED symptoms, anxiety sensitivity, and interoceptive deficits between baseline and the final intervention session. However, the magnitude and durability of these changes varied among participants, suggesting that further investigation is needed to determine whether IE is differentially effective for various ED symptoms or particular diagnostic groups.

Outcome data for the 4 participants suggests that IE can be a useful strategy to target interoceptive deficits and subjective distress associated with somatic cues of anxious arousal and eating/digestion. Ratings of distress for the most personally relevant IEs consistently decreased among the participants, with distress ratings halved or non-existent for some participants and IEs. Decreases in distress did not consistently coincide with documented between-session homework completion, however. Challenges to patient engagement in IE exercises must be carefully considered, and provide critical information for future testing of this intervention.

In particular, exposure interventions evoke uncomfortable sensations and emotions. Exposure-based interventions may coincide contemporaneously with exacerbations in symptoms (secondary to promoting approach to feared sensations), yet lead to longer-term benefits (Hayes & Strauss, 1998). Anecdotally, at the point of recruitment and during discussions about IE homework, potential and actual participants might have underplayed concerns regarding expected discomfort and approaching feared and avoided sensations. Rather, the primary concerns raised were practical, including already devoting many hours per week to treatment in the IOP and struggling to find time outside of the program due to other obligations.

Given the focus of IE on hypothesized maintenance factors of EDs (i.e., anxiety sensitivity and interoceptive deficits), it seems plausible that the beneficial effects of IE on eating pathology would emerge at longer-term follow-up, given that changes in anxiety sensitivity would likely precede lasting change in ED behaviors. Case D demonstrated large reductions in interoceptive deficits, with increased improvement observed at one-month follow-up. This participant was also 100% compliant with weekly homework. However, EDE-Q symptoms slightly increased for this participant, so there is little evidence of a direct link between interoceptive deficit change and ED symptom change in this case. It is important to note, however, that Case D entered the study with relatively low global ED scores.

Furthermore, research on treatment for EDs, suggests that although many treatments demonstrate short-term benefits on weight and cognitive pathology, relapse is common, and short-term gains are not maintained at follow-up (Hay, 2013). As such, interventions like IE that target proposed mechanisms of EDs may be most beneficial in disrupting relapse and promoting maintenance of treatment gains, rather than promoting increased symptom change during treatment. Future work should evaluate longer-term effects of the IE intervention on hypothesized symptoms and mechanisms.

Given the preliminary nature of this research, we were primarily interested in establishing the acceptability and feasibility of IE for use in EDs. Both observational and behavioral data suggests mixed findings regarding the feasibility and acceptability of this approach as conducted. First, it is important to highlight that no adverse events occurred in administration of IE within this IOP setting, suggesting that engagement in these exercises is safe for individuals currently engaged in intensive outpatient treatment for EDs. In addition, attendance throughout IE sessions, combined with participant feedback and discussion with researcher-facilitators, indicated that the IE exercises and associated distress were tolerable over the course of sessions. Further, half of the participants who completed the 4-session intervention informed research staff that they had asked their individual therapists to continue with IE work following study completion, suggesting that these participants experienced benefits associated with the intervention and despite promoting temporary discomfort, found it to be acceptable.

However, despite positive indicators of feasibility and acceptability, other indices highlighted important areas for improvement. For instance, homework completion, which we conceptualized as a behavioral measure of acceptability, was variable. One participant with less than 50% compliance routinely reported that she had completed daily assignments, yet forgot to bring her IE rating forms during weekly sessions with study therapists. Although homework compliance was variable, it is notable that meaningful reductions in distress were observed with the exposure "dose" ostensibly limited to the study sessions.

Anecdotally, this lack of compliance was not specifically attributed

to IE, as face-to-face participant reports indicated that the IE was tolerable. It is, however, unclear if the relatively low compliance observed is specifically due to IE, assignment of exposure-related homework in general, or perhaps even more general homework compliance issues that have been documented in psychological treatments (Kazantzis, Deane, & Ronan, 2004). For example, study therapists noted that several participants reported finding that daily homework was difficult due to schedule demands, as participants were in IOP-level treatment (3–4 days per week, 3 h per day), received once-weekly individual outpatient CBT sessions, and also attended regular dietician and other medical appointments. Further, given that many participants in IOP were simultaneously attending school and/or were employed part-time, they also indicated that it was difficult to prioritize daily IE. Altogether, it seemed that participants may have found daily IE homework particularly burdensome for IOP-level care. Although it is possible that poor homework adherence reflected avoidance tendencies characteristic of both anxiety and EDs, it is not possible to determine this from the available data. Future work should investigate ways to increase homework adherence when faced with time and perceived participant burden in IOP and other levels of care, as well as evaluate whether there may be a dose-response effect of daily homework completion, in order to ensure participant engagement in IE treatment.

One particularly important future direction for work on adjunctive IE for use in EDs concerns the optimal format and administration of the intervention. We chose to administer IE in a 4-session format during the course of regular IOP. Future work should evaluate whether variable doses of treatment, ideally idiographically determined by patient-specific symptom change and needs, have similar effects and explore whether there is an optimal time within treatment to target anxiety sensitivity and interoceptive deficits. For each participant, sessions were guided based upon report of which exercises invoked the most distress. Notably, for one individual, the traditional (i.e., non-ED related) exercises were the most salient, underscoring the importance of individualizing this intervention. Many IOP ED treatments rely considerably on a group format for treatment, thereby suggesting that IE interventions, which are idiographic in nature, may need to be scheduled with individual patients outside of regular group meeting time. Conversely, conducting IE within a group format may hold particular value in normalizing discomfort and facilitating new learning based on physical experience within group discussion, a possibility that warrants further investigation.

In addition, offering this intervention as adjunctive to standard IOP treatment resulted in recruitment difficulty. It is difficult to discern whether this was a consequence of the additional burden of time devoted to treatment, above and beyond IOP, or if lack of voluntary participation was secondary to avoidance of potential discomfort anticipated in the exercises. Based on our experiences, researchers interested in further testing IE for EDs may consider preempting these issues through (1) recruiting from outpatient samples, where treatment demands are fewer and would presumably allow enhanced engagement, or (2) when feasible, conducting a pre-recruitment, detailed psychoeducational group for patients in intensive treatment settings that more specifically outlines the conceptualization of avoidance in the maintenance of eating disorder symptoms (Pallister & Waller, 2008) and openly addresses common concerns or misconceptions that individuals may have regarding exposure therapy (Deacon et al., 2013).

Finally, particularly as related to use of IE within AN, the effects of weight restoration processes on the gastrointestinal system are important to consider and may have implications for the timing of interventions probing gastric-specific interoceptive processes (Bluemel et al., 2017). Specifically, future work should consider whether it is prudent to wait to administer IE interventions until after weight restoration is complete and gastric processes have normalized.

### 4.1. Limitations

The current study was a preliminary case series that was embedded in a naturalistic IOP setting. Results should be considered cautiously, and several limitations must be noted. First, this study involved a small, self-selected sample, which significantly limits generalizability. Nevertheless, it is important to emphasize that study participants were drawn from a naturalistic sample of IOP patients, and case series studies are not aimed at generalizability in the traditional sense (Barlow, Nock, & Hersen, 2009). Rather, the case series approach was aimed at establishing feasibility and tolerability of experimental interventions in a new population, as well as preliminarily demonstrating the potential to impact hypothesized transdiagnostic targets.

There were also limitations associated with the nature of the data collected. With the exception of repeated within-session distress ratings, measurements of key variables involved standardized measures administered at mostly weekly intervals. This assessment schedule may not have been sensitive enough to pick up the most relevant changes in symptoms and processes over time. This limited our ability to perform rigorous inferential tests. Calculations of within-person effect sizes and change have also been the focus of debate, and the descriptive results reported herein must be considered tentatively. In addition, there were a number of threats to internal validity. For example, all participants were in active IOP treatment, which included group, individual therapy, and dietician meetings. We did not control or account for the level of alternative treatment provided. However, given that IE was not a component of any other treatment modality for the participants (current or past), the design can be conceptualized as pseudo-additive. In addition, we did not stratify for primary diagnosis or comorbidity. Consequently, we cannot draw conclusions about the impact of IE on specific primary EDs.

Although the current study was initially intended to be an experimental case series, the difficulty with recruitment represents one factor that limits interpretation of the current findings and warrants consideration for future investigation of the utility of IE for EDs. In particular, interpretation of the current data is likely limited to individuals seeking IOP-level treatment and, therefore, reflects the level of involvement that one might observe from IOP patients, but not others. For instance, IOP patients spend a lot of time in treatment. Unlike in more constrained residential treatment, IOP patients can opt out of anything that is perceived to be “extra” to their already intensive treatment regimen. Even with a monetary incentive and the potential for incremental treatment benefit, the prospect of spending “free time” at the site was reported to be daunting. The complex nature of the IOP setting and program also impacted data collection. It is difficult to find space for research in such settings, yet participants were given privacy while completing the survey items on the computer. Altogether, it seems likely that recruitment rates and patient participation in IE would differ in other populations that had fewer time conflicts, such as individuals receiving once-weekly outpatient therapy sessions, or individuals in residential treatment centers who have no competing time demands (e.g., work, school). Further, all of the above underscores the difficulty of conducting research in naturalistic settings, a context in which single case studies and related designs can be particularly fruitful for science-practice integration and the advancement of practice-based evidence.

A large body of research has suggested that EDs are associated with elevated anxiety sensitivity, and disturbed interoceptive processing may be involved in the onset and maintenance of EDs. For this reason, evidence-based treatment techniques used in other conditions characterized by altered interoceptive processing, such as panic disorder, are worthy of further investigation. The current pilot investigation provides an example of how IE may be adapted for use in EDs, and to our knowledge is the first test of the impact of this technique as an augmentation of traditional intensive-outpatient CBT. Findings generally support continued consideration of IE within this population and

suggest that, although further refinement and empirical testing of this intervention is warranted, it represents a promising new direction for improving outcomes and preventing relapse within these devastating conditions.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2019.02.004.

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