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EATING DISORDERS**Eating disorder symptomatology and body mass index are associated with readers' expectations about character behavior: Evidence from eye-tracking during reading**

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Eating disorder symptomatology and body mass index are associated with readers’ expectations about character behavior: Evidence from eye-tracking during reading

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Abstract

Objective: Many theories have been put forward suggesting key factors underlying the development and maintenance of eating disorders, such as: unhealthy food-related cognitive biases, negative body attitude, and perfectionism; however, underlying cognitive processes associated with eating disorder symptomatology remain unclear. We used eye-tracking during reading as a novel implicit measure of how these factors may relate to eating disorder symptomatology. **Method:** In two experiments, we monitored women's eye movements while they read texts in which the characters' emotional responses to food-, body image-, and perfectionism-related scenarios were described. Participants' eating disorder symptomatology was then assessed. **Results:** Both studies suggest that moment-to-moment processing of characters' emotional responses to perfectionism-, and to a lesser extent, body image-related information was associated with participants' eating disorder symptomatology, thus supporting theories in which these factors are key to developing and maintaining eating disorders. Interestingly, the moment-to-moment processing of characters' emotional responses to food-related scenarios was not related to eating disorder symptomatology. **Discussion:** These findings provide novel insights into cognitive processes underlying eating disorder symptomatology, as well as demonstrating the utility of more natural implicit measures.

Keywords: Eating disorders; reading; eye-tracking; food; perfectionism; body attitude

Eating disorder symptomatology and body mass index are associated with readers' expectations about character behavior: Evidence from eye-tracking during reading

Better understanding of the cognitive mechanisms (e.g., 'thin-ideal'), or information processing strategies underlying eating disorders is arguably critical to aid in the development of preventative and treatment methods. Many theorists have proposed that these mechanisms are based on selective attention towards negative food- and/or body-related stimuli (e.g., Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Shafran, Lee, Cooper, Palmer, & Fairburn, 2007; Williamson, White, York-Crowe, & Stewart, 2004). In addition, several theories indicate that perfectionism is a key aspect of the etiology of eating disorders (e.g., Bardone, Vohs, Abramson, Heatherton, & Joiner, 2000; Fairburn, Cooper, & Shafran, 2003; Treasure & Schmidt, 2013; Vitousek & Hollon, 1990). However, there is currently little empirical evidence clarifying the underlying cognitive mechanisms associated with eating disorder symptomatology.

Traditionally, studies have relied solely on self-report measures (e.g., Rohde, Stice, & Marti, 2015), however, more implicit measures may be crucial to investigate factors underlying eating disorder symptomatology while avoiding social desirability bias. Commonly used implicit methods include the modified Stroop task and dot-probe task (e.g., Redgrave et al., 2008; Rieger et al., 1998), which may tap into more implicit biases than questionnaire studies but involve unnatural tasks.

Several studies have utilized eye-tracking to investigate the processing of body- and/or food-related stimuli, primarily for body or weight dissatisfaction in non-clinical samples (e.g., Gao et al., 2014; Glashouwer, Jonker, Thomassen, & de Jong, 2016; Jansen, Nederkoorn, & Mulken, 2005). For instance, despite self-reported improvement of reduced shape concern and

1 eating disorder symptoms, Glashouwer et al. (2016) reported that women with high body
2 dissatisfaction attended to 'ugly' body parts longer than 'beautiful' ones for both their own and
3 other people's body images, after a five-week body positivity training. Thus, it may be the case
4 that eye-tracking is a more sensitive objective measure than self-report.

5 Eye-tracking within the clinical eating disorder population has primarily been used to
6 investigate the processing of images of bodies (e.g., George, Cornelissen, Hancock, Kiviniemi,
7 & Tovée, 2011; Phillipou et al., 2016; von Wietersheim et al., 2012) or has examined the free
8 viewing of food images (e.g., Giel et al., 2011). For example, in George et al.'s (2011) study,
9 women judged the attractiveness and body-size of other women with lower and higher BMI than
10 themselves, and found that participants with anorexia nervosa fixated on bony body areas (i.e.,
11 hip-, collar-bone, etc.) when making judgments, compared to controls. In von Wietersheim et
12 al.'s (2012) study, women rated self- versus other-body attractiveness. They found that
13 participants with anorexia nervosa fixated on their own thighs, and were more critical, compared
14 to controls. Schmidt, Lüthold, Kittel, Tetzlaff, and Hilbert's (2016) visual search study found
15 adolescents with binge-eating disorder more quickly detected and maintained fixation on food
16 images compared to controls. Giel et al.'s (2011) free viewing study reported no initial food
17 image patterns, followed by avoidance of these images for participants with anorexia nervosa,
18 compared to controls, confirming the utility of eye-tracking as a tool to monitor changes in
19 processing strategy over time. Although eye-tracking detected processing differences between
20 participants with an eating disorder and controls, since these studies often demanded explicit
21 comparisons, the nature of the task may have influenced participants' behavior.

22 In contrast, tracking eye movements during reading is noted to be an exceptional way of
23 examining underlying cognitive processes whilst participants are performing a task that is part of

1 their natural, everyday behavior; that is, simply reading text from a computer screen (Liversedge
2 & Findlay, 2000). The approach taken here is based on established evidence that during a
3 natural reading task, participants' eye movement behavior demonstrates that they can quickly
4 detect when a character in a story behaves in contrast to the reader's expectations, illustrated by
5 more disruption to eye movements when reading about unexpected relative to expected behavior
6 (e.g., Filik, 2008; Filik & Leuthold, 2008, 2013). Importantly, this finding extends to the
7 anticipated emotional reaction of the character to an event that is described in the text (e.g., Filik,
8 Brightman, Leuthold, & Gathercole, 2017).

9 Thus, in the current study, we employ eye-tracking during reading to implicitly
10 investigate participants' expectations regarding how a character might react in certain situations,
11 and how these expectations might be related to indices of eating behavior. To our knowledge,
12 this is the first research to use measures of moment-to-moment language processing to
13 investigate factors related to eating behavior. Specifically, we conducted two experiments in
14 which women recruited from a community population read food-related, body image-related, and
15 perfectionism-related scenarios, in which the target sentence contained a critical emotion-based
16 word (e.g., *pleased* in Table 1) which would either 'match', or 'mismatch' with the reader's
17 expectations regarding how the character might react (e.g., Leuthold, Filik, Murphy, &
18 Mackenzie, 2012). To determine participants' levels of eating disorder symptomatology,
19 following the eye-tracking task, they completed the Eating Disorder Examination Questionnaire
20 (EDE-Q 6.0; Fairburn & Beglin, 2008), which is the only measure of eating disorder pathology
21 currently recommended by the National Institute for Mental Health in England (2008).
22 Participants' body mass index (BMI) was also calculated, as individuals' processing strategies
23 regarding disease salient information may also be associated with BMI.

1 If eating disorder symptomatology is primarily associated with processing of food-related
2 information (e.g., as found by Brooks et al., 2011), then we would predict that participants' eye
3 movement behavior while reading food-related items would be associated with their scores on
4 the EDE-Q 6.0. In relation to the example given in Table 1, if participants have a focus on
5 unhealthy food, they may experience more processing difficulty integrating the word *pleased* in
6 the mismatch condition, since in this condition the character is pleased that they have eaten an
7 entire tub of ice-cream. Specifically, we would predict that the size of the 'mismatch effect'
8 (reading time in the mismatch condition minus reading time in the match condition) would be
9 larger in participants with food-related biases. If such biases are key determiners of eating
10 disorder symptomatology, then we expect that participants with larger mismatch effects would
11 show higher scores on the EDE-Q 6.0. As a secondary level of analysis, since low weight is a
12 key DSM-V diagnostic criterion for anorexia nervosa (American Psychiatric Association, 2013),
13 and higher BMI is often associated with bulimia nervosa or binge-eating disorder (see for
14 example; Hudson, Hiripi, Pope, & Kessler, 2007; Treasure et al., 1999; Weissman & Rosselli,
15 2017), we also expect the size of the mismatch effect to be associated with individuals' BMI.

16 In contrast, if body image-related information processing is key (e.g., as found by
17 Shafran et al., 2007), then we would predict that the level of processing difficulty experienced on
18 encountering the word *pleased* in the mismatch (her doctor comments that she has gained quite a
19 bit of weight) compared to the match condition (her doctor comments that she has lost quite a bit
20 of weight) would be associated with eating disorder symptomatology and/or BMI. If
21 perfectionism is a key factor underlying the development of eating disorders, then we instead
22 expect that participants' eating disorder symptomatology would be associated with the size of the
23 mismatch effect for perfectionism-related materials. Finally, it may also be the case that some

combination of these factors is associated with eating disorder symptomatology (such as body, food, and perfectionism, proposed by Fairburn et al., 2003). As men and women may have different expectations and goals, such as desired body-type (e.g., Ralph-Nearman & Filik, 2018), we only recruited women for this study.

Experiment 1

Method

Participants

Ninety native English-speaking women aged 18-38 ($M = 21.39$, $SD = 4.37$) with normal or corrected-to-normal vision and no history of neurological illness or reading disabilities were recruited from the Nottingham area to take part in a reading/eye-tracking study. None of the individuals reported having a clinical eating disorder diagnosis (but this was not an exclusion criterion). The appropriate Ethics Review Board approved the study; all participants gave written consent. Participants were not informed of the aims of the study prior to taking part, in order that this information would not influence their behavior, but they were fully debriefed following participation.

Materials and Design

Thirty-six short texts were created and pre-tested, which consisted of food-, body image-, or perfectionism-related third-person scenarios (see Table 1 and Supplement). Six counterbalanced lists were created, each including one version of each item, with equal numbers of items in each of the six conditions, along with 46 filler items. Each scenario ended with a target sentence, displayed on a single line, containing a critical emotion-based word (e.g., *pleased*, *upset*) that either ‘matched’ or ‘mismatched’ with one’s expectations concerning how

the character might react. Thus, the experiment consisted of a 3 *dimension* (food vs. body image vs. perfectionism) x 2 *match* (match vs. mismatch) design, with both dimension and match as within-subjects and within-items factors. Participants' EDE-Q 6.0 score (Fairburn & Beglin, 2008) and BMI were calculated.

-----Table 1 inserted about here-----

Procedure

An SR Research EyeLink 1000 eye-tracker was used to track each participant's eye position every millisecond. Materials were displayed on a 17-inch monitor 56 cm from the participants' eyes. Prior to the experiment, each participant was given a questionnaire, to identify any prior diagnoses of neurological or psychological disorders (including an eating disorder), a consent form and instructions. Then the participant was seated at the eye-tracker and given the instruction to read normally. Before the start of the experiment, participants completed a full-screen 9-point calibration procedure (average error < 0.5 degrees of visual angle), and two practice trials. After reading each item, they pressed the right-hand trigger on a hand-held controller to proceed to the next trial. To ensure that participants were reading for comprehension, a comprehension question was displayed following 25% of trials. An average accuracy rate of 94% confirmed that participants were engaged in the task. Finally, participants completed the EDE-Q 6.0 and provided their height and weight onsite on a computer (Qualtrics.com).

Eye-tracking Data Analysis

Materials were divided into analysis regions (see Table 1) and reading times for the target sentence containing the emotional response are reported. *Region 1* was the first portion of the target sentence (e.g., *She is very*), up to the critical emotional target word. *Region 2* comprised

the emotional target word (e.g., *pleased*), and was the first point at which participants may be able to infer that the described emotional response either matches or mismatches with their expectations. *Region 3* consisted of the remainder of the target sentence (e.g., *to have done that*). Fixations under 80 ms were integrated into larger adjacent fixations within one character and fixations under 40 ms which were not within three characters of another fixation, and those over 1200 ms, were deleted. Prior to analysis, all trials with zero first-pass reading times in two or more adjacent regions (and also any trials where participants had not read the second sentence of the context - the content of which is crucial in determining whether the target sentence should be a match or a mismatch), were removed (i.e., we removed trials with significant track losses). Following this procedure, 7.50% of the data were removed.

If a reader experiences processing difficulty when encountering text which indicates that a character is *pleased* when it would be expected that the character is very unhappy within the context of the scenario, the reader may respond to this processing difficulty in a number of different ways. These are captured by calculating a number of different measures of reading behavior across different regions of the target sentence (e.g., *She was very^{Region 1} pleased^{Region 2} to have done that.^{Region 3}*) (see Table 1 and Supplement for examples; Table 2 for eye-tracking measure definitions).

----Table 2 inserted about here----

If participants very rapidly detect the anomaly, this may be apparent in their initial fixations (captured by *first fixation duration* and *first-pass reading times*) on the critical regions of text, with longer fixations in mismatching conditions (e.g., Filik et al., 2008; Warren & McConnell, 2007). First fixation (or first-pass) effects may be observed on the critical emotion word itself (Region 2), or on the region of text immediately following the target word (Region

3), reflecting ‘spillover effects’ (e.g., Clifton, Staub, & Rayner, 2007), that is, reflective processing of critical information which continues after the eyes have moved on to the next region of text (Rayner, 1998).

Readers may also look back (i.e., make a *regression*) to re-read earlier parts of the text to further process the unanticipated information (e.g., Filik et al., 2008; Rayner, Warren, Juhasz, & Liversedge, 2004; Warren, McConnell, & Rayner, 2008). This behavior is captured by *regression path reading times*. Finally, the reader may take more time overall to process information in any of the regions of the target sentence, which would be captured in the *total reading time* for each region, which includes time spent initially fixating the region, plus any time spent re-reading it. In sum, four standard measures of reading behavior are reported in order to capture all of the possible ways in which the reader may respond to unexpected information in the text, providing a detailed and moment-to-moment picture of implicit information processing, and how this relates to eating disorder symptomatology.

Prior to analysis, we removed all trials with zeros for each reading time measure in each region. This procedure accounted for 18.95% of data in *Region 1*, 12.51% in *Region 2*, and 0.33% in *Region 3*, for first fixation duration, first-pass reading time, and regression path reading time; and 5.01% in *Region 1*, 9.14% in *Region 2*, and 0.33% in *Region 3* for total reading times, which is in the normal range (e.g., Rayner, 2009).

Results

Data for each of the three regions in the critical sentence were analyzed using two 3 *dimension* (food vs. body image vs. perfectionism) x 2 *match* (match vs. mismatch) ANOVAs, one considering participants (*F1*) and one considering items (*F2*) as random variables (see Table 3 for descriptive statistics; Table 4 for ANOVA results). Modeling participants (*F1*) and items

(*F*²) as random variables enables effects to be generalized across both participants and linguistic materials (Clark, 1973).

Region 1 (e.g., *She is very*)

There were longer total reading times in mismatching than matching conditions, suggesting that readers had gone back and re-read earlier portions of the text in mismatching conditions. No other effects were significant by both participants and items.

Region 2 (e.g., *pleased*)

There were again longer total reading times for mismatching than matching conditions. This effect was not present in earlier measures of reading time (first fixation duration, first-pass), suggesting that readers did not pick up on the mismatch straightaway. No other effects were significant by both participants and items.

Region 3 (e.g., *to have done that.*)

There were longer regression path and total reading times for mismatching than matching conditions. In regression path, there was also a main effect of dimension. Paired samples t-tests with Bonferroni correction ($p < .008$) indicated that the average for the match and mismatch conditions for the perfectionism dimension ($M = 1269, SE = 65.1$) was significantly higher than the food dimension ($M = 1112, SE = 50.0$), $t(89) = 3.67, p < .001$; $t(35) = 3.80, p = .001$, and also higher than the body image dimension by participants but not by items ($M = 1117, SE = 56.0$), $t(89) = 3.28, p = .002$; $t(35) = 2.49, p = .02$. There was no difference between food and body image dimensions ($ts < .43, ps > .67$). No other effects were significant by both participants and items.

-----Insert Table 3 about here-----

-----Insert Table 4 about here-----

BMI and EDE-Q 6.0 Score Analysis

Participants' BMI (Kg/M^2) was calculated, which ranged from 16.3 (very underweight) to 33.7 (obese) ($M = 22.57$, $SD = 3.86$). Each participant's Global EDE-Q 6.0 score was computed by summing the four subscales and dividing by four; scores may range from 0 (lower eating disorder symptomatology) to 6.0 (higher eating disorder symptomatology). Participants scored from 0 to 5.65 ($M = 1.70$, $SD = 1.23$), which is slightly higher than community norms ($M = 1.52$, $SD = 1.25$) (Mond, Hay, Rodgers, & Owen, 2006). The Cronbach's alpha coefficient was reliable (.95).

Examining the Relationship Between Reading Behavior and Eating Behavior

Firstly, we calculated a mismatch effect score (mismatch – match reading times) for each measure of reading time in each region for each dimension. In order to investigate whether the way in which a reader processes food-, body-, and perfectionism-related materials is associated with eating disorder level and/or BMI, we conducted regression analyses, using the enter method, with the size of the mismatch effect (mismatch – match for each dimension) as a predictor variable, and the participant's score on the EDE-Q 6.0 and BMI as the criterion variables. Pre-analysis checks indicated no concerns for EDE-Q 6.0 or BMI regressions (Cook's Distance $\leq .185$; $\leq .094$; Durbin-Watson = 2.082; 1.716; Tolerance = .946; 1.000; Variance Inflation Factor (VIF) = 1.001; 1.000). Importantly, a lack of an overall significant mismatch effect in a particular region or measure does not mean that the size of the mismatch effect across participants cannot vary in relation to our measures of interest.

In relation to the EDE-Q 6.0, the size of the mismatch effect for perfectionism-related materials in total reading time for *Region 1* was associated with eating disorder symptomatology. Specifically, participants with a *smaller* mismatch effect showed higher levels of eating disorder

1 symptomatology, which would be in contrast to the prediction of a *larger* mismatch effect
2 resulting in higher eating disorder symptomatology levels. However, in first-pass reading times
3 for *Region 2*, a larger perfectionism-related mismatch effect score was associated with higher
4 eating disorder symptomatology, which is in the expected direction. Also, regression path
5 reading times for *Region 2* revealed that larger body image-related mismatch effect scores were
6 associated with higher eating disorder symptomatology to a slightly lesser extent, which was also
7 in the expected direction (see Table 5a).

8 In relation to BMI, for total reading time for *Region 1*, *larger* perfectionism-related
9 mismatch effect scores were associated with *lower* BMI (see Table 5b).

10 ----Insert Table 5a and 5b about here----

11 In summary, results from Experiment 1 suggest that the way in which participants
12 process perfectionism- and body image-related information may play a role in eating disorder
13 symptomatology and BMI. Since eating disorder symptomatology has been linked to self-focus
14 and internalization (Durso et al., 2012), and there is evidence of perspective effects on eye
15 movements during the processing of emotional information within text (see Filik et al., 2017),
16 we decided to replicate and extend the findings from Experiment 1 with a similar study in which
17 the materials were designed to encourage the participants to read the materials from their own
18 perspective. Evidence suggests second-person-perspective (i.e., ‘You’), rather than first-person-
19 (i.e. ‘I’) or third-person-perspective (i.e., ‘She’ or ‘Jane’), leads to readers experiencing stronger
20 emotional personalization of texts (see Brunyé, Ditman, & Mahoney, 2011). Therefore, we
21 altered the character names to second-person-perspective in Experiment 2 (i.e., replacing ‘Jane’
22 or ‘She’ with ‘You’). In addition, participants’ height and weight were physically measured, in
23 order to gain an objective calculation of their BMI.

Experiment 2

Method

Participants

Ninety native English-speaking women aged 18-36 ($M = 20.50$, $SD = 2.97$), fitting the same criteria as Experiment 1, took part. Again (although not a criterion for inclusion or exclusion), none of the participants reported having a prior eating disorder diagnosis.

Stimulus Materials, Design, Procedure & Eye-tracking Analysis

The stimulus materials from Experiment 1 were slightly altered to be directed at the participant in second-person (i.e., 'You' replaced 'She') (see Supplement), and participants' actual height and weight were measured. Otherwise, the design and procedure were all identical to Experiment 1.

Prior to analysis, 6.33% of the data were removed due to track losses, following the same procedure as in Experiment 1. Also removed were all trials with zeros for each reading time measure in each region (only prior to each of the individual analyses): 21.01% of data in *Region 1*, 6.99% in *Region 2*, and 1.09% in *Region 3* for first fixation duration, first-pass, and regression path reading time; and 6.99% in *Region 1*, 11.83% in *Region 2*, and 0.89% in *Region 3* for total reading times. An average accuracy rate of 89% for the comprehension questions confirmed that the participants were engaged in the task.

Results

Eye-tracking analysis was also identical to Experiment 1 (see Table 6 for descriptive statistics; Table 7 for ANOVA results).

Region 1 (e.g., You are very)

There were longer total reading times for mismatching than matching conditions, indicating that participants spent more time re-reading the beginning of the target sentence in mismatch conditions. No other effects reached significance by both participants and items.

Region 2 (e.g., pleased)

As in Region 1, there were longer total reading times in mismatching than matching conditions. No other effects reached significance by both participants and items.

Region 3 (e.g., to have done that.)

There were longer regression path and total reading times for mismatching than matching conditions. Regression path also showed a main effect of dimension. Post-hoc paired samples t-tests with Bonferroni correction ($p < .008$) indicated that the mean score averaged over match and mismatch conditions for the perfectionism dimension ($M = 1202, SE = 70.2$) was significantly higher than the food dimension ($M = 983, SE = 65.7$), $t_1(89) = 3.79, p < .001$; $t_2(35) = 3.67, p = .001$, but not the body dimension ($M = 1073, SE = 63.9$), $t_s < 2.41, p_s > .018$. There were also no differences between food and body dimensions ($t_s < 1.87, p_s > .070$). No other effects reached significance by both participants and items.

---Insert Table 6 about here---

---Insert Table 7 about here---

BMI and EDE-Q 6.0 Score Analysis

Participants' BMI scores ranged from 17.8 (underweight) to 38.2 (obese) ($M = 22.39, SD = 3.30$), and Global EDE-Q 6.0 scores ranged from .16 to 5.30 ($M = 1.84, SD = 1.27$), again slightly higher than community norms ($M = 1.52, SD = 1.25$) (Mond et al., 2006). The Cronbach's alpha coefficient was reliable (.95).

Examining the Relationship Between Reading Behavior and Eating Behavior

Mismatch scores were computed, followed by regression analyses. Pre-analysis checks indicated no concerns for EDE-Q 6.0 or BMI regressions (Cook's Distance $\leq .287$; .253; Durbin-Watson = 2.421; 1.722; Tolerance = .998; 1.000; VIF = 1.002; 1.000).

The EDE-Q 6.0 score results showed that for first fixation duration for *Region 3*, (e.g., *to have done that.*), larger perfectionism-related mismatch effect scores (mm) were associated with higher eating disorder symptomatology (see Table 8a), which is in the expected direction.

Larger mismatch effect scores for total reading times for perfectionism-related materials in *Region 3*, (e.g., *to have done that.*) were associated with lower BMI. In first fixation duration for *Region 2* (e.g., *pleased*), larger body-related mismatch effect scores were associated with lower BMI (see Table 8b).

---Insert Table 8a and 8b about here---

Discussion

The current study revealed a number of findings. Firstly, the results showed a mismatch effect for all three dimensions (food, body-image, and perfectionism) when materials were presented from both a third-person (Experiment 1) and a second-person (Experiment 2) perspective. This mismatch effect suggested that participants may have generally expected the character to have a negative response to gaining weight, eating a lot, and minor mistakes, and a positive response to losing weight, eating less, and making no mistakes. These results support and extend several concepts, such as implicit anti-fat bias attitudes and stereotypes, reported in young children (e.g., Rodgers, Wertheim, Damiano, Gregg, & Paxton, 2015), and obesity-focused healthcare professionals (e.g., Teachman & Brownell, 2001). Perfectionism-related stimuli may be considered "ego-threats", as the lack of perfection is perceived by the reader as a "threat" to self-image, which is reported to reduce when threatened, such as with poor academic

performance (Vohs & Heatherton, 2001). Therefore, participants may have generally expected the character to have a negative (rather than positive) response to a small mistake.

Analysis of the relationship between reading behavior and eating behavior showed that the size of the mismatch effect for body image-related materials was associated with higher eating disorder symptomatology in regression path reading times for Region 2 (the emotion word) for scenarios about other characters (Experiment 1), and also was associated with lower BMI in first fixation duration for Region 2 in scenarios about participants themselves (Experiment 2). Therefore, more difficulty experienced in processing scenarios in which the character was, for example, *pleased* about gaining a lot of weight, was associated with higher eating disorder symptomatology (Experiment 1), and lower BMI (Experiment 2).

The size of the mismatch effect for perfectionism-related materials had a more pervasive influence, being consistently associated with both eating disorder symptomatology and participants' BMI across a number of different regions and measures of reading time. Specifically, in Experiment 1, results for perfectionism-related materials showed that a larger mismatch effect in first-pass reading times for Region 2 were associated with higher levels of eating disorder symptomatology. However, in total reading times for Region 1 (which includes any re-reading of the beginning of the critical sentence) we found the opposite pattern, specifically, that a *smaller* mismatch effect in perfectionism-related scenarios was associated with higher eating disorder symptomatology. To speculate, it may be that initially, participants with higher levels of eating disorder symptomatology spent longer processing emotional responses that do not fit with their expectations (e.g., being happy about failure). However, since such scenarios may be perceived as threatening to themselves (Waller & Meyer, 1997) those with higher eating disorder symptomatology may have avoided going back and re-reading

portions of the critical sentence. Nevertheless, we did find that larger mismatch effects in total reading times for perfectionism-related scenarios in Region 1 were associated with a lower BMI. Limitations of Experiment 1 are that we cannot confirm the accuracy of participants' self-reported BMI, or that they were all taking the same perspective when reading the materials, since the third-person scenarios employed were about fictional characters.

Thus, to be more certain that participants were reading the materials from their own perspective, and since previous studies report that utilizing 'You' instead of 'She' influences the personalization of emotions within the text (see Brunyé et al., 2009), we conducted Experiment 2 in which materials were written in the second-person (about the reader) rather than about a character. We also recorded actual BMI-related measurements (i.e., height and weight). Results from Experiment 2 showed a clear and consistent pattern of effects, in that a larger mismatch effect for perfectionism-related materials was significantly associated with higher eating disorder symptomatology, and both a larger mismatch effect for perfectionism-related materials and body-related materials showed significant associations with lower BMI.

Therefore, it appears that tracking eye movements during reading may be informative regarding the underlying cognitive mechanisms associated with eating disorder symptoms and BMI, and the timecourse over which they come into play when processing relevant information. That is, the current results showed that higher eating disorder symptomatology and lower BMI were associated with longer early reading time measures on the unexpected emotional word itself (e.g., *pleased*) and just after this response (the *spillover effect*), indicating initial difficulty in processing an unexpected response. This was then sometimes followed by an avoidance of re-reading the target sentence within perfectionism-related contexts. The findings relating to early processing measures provide some support for the suggestion that individuals with eating

disorders find it difficult to shift their cognitive focus (lower cognitive flexibility) during initial information processing (e.g., Lang, Lopez, Stahl, Tchanturia, & Treasure, 2014; Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007). Findings in later measures may suggest later avoidance-related emotional processing of disease-salient stimuli (see Cisler & Koster, 2010).

Limitations point to avenues for future investigation, including examining generalizability beyond native English-speaking females, and further investigation of differences related to perspective changes. We recruited from a community sample for both experiments, and although not a criterion for inclusion or exclusion, we cannot rule out the possibility that some participants may have had an eating disorder (which was not reported or not clinically diagnosed), given that some in papers reporting EDE-Q 6.0 norms, a cutoff ≥ 4 is considered to indicate clinically significant or severe eating disorder symptomatology (Carter, Stewart, & Fairburn, 2001; Luce, Crowther, & Pole, 2008). In addition, both Experiment 1 and 2's Global EDE-Q 6.0 mean scores were slightly higher (ranging from 0 to 5.65 and .16 to 5.30) than reported in some other studies, for example, Mond et al.'s (2006) Australian community sample norms (.04 to 4.97 Global score range). However, since eating disorder symptoms are known to fluctuate between individuals, samples, and countries (e.g., Mond et al., 2006; Tozzi et al., 2005), this difference in scores is perhaps not surprising. Finally, it should be noted that our present experiments are not a study of "risk factors" for the development or maintenance of an eating disorder (in the way in which the term is defined by Jacobi, Zwaan, Hayward, Kraemer, & Agras, 2004), since we did not adopt the "gold standard" longitudinal design that is proposed to allow for a definitive test of a risk- or maintenance-factor hypothesis.

In conclusion, the results principally support theories which include perfectionistic information processing style as both a risk and maintenance factor for eating disorders, such as

1 the Cognitive-Interpersonal Model of Anorexia Nervosa (e.g., Treasure & Schmidt, 2013).
2 However, since results also showed that body-image related conditions played a role, the current
3 findings may most strongly support (and extend) Fairburn et al.'s (2003) Transdiagnostic Model
4 of Eating Disorders, pointing to general perfectionism and body-image related information
5 processing as key underlying cognitive mechanisms of eating disorder symptomatology. Thus,
6 these eye-tracking results provide novel insights into cognitive processes underlying eating
7 disorder symptomatology, as well as demonstrating the utility of more natural implicit measures,
8 which may now be extended to investigate clinical populations, non-English speaking natives,
9 and males.

10

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Table 1

Example Material from Experiment 1 with analysis regions.

Scenario Type	Example
<i>Food-related Match</i>	Barb stops by the shop on her way home from work./ She gets a large tub of ice cream, and goes home and eats a small portion./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /
<i>Food-related Mismatch</i>	Barb stops by the shop on her way home from work./ She gets a large tub of ice cream, and goes home and eats the whole thing./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /
<i>Body image-related Match</i>	Barb goes in for a regular check-up./ Her doctor comments that she has lost quite a bit of weight since her last appointment./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /
<i>Body image-related Mismatch</i>	Barb goes in for a regular check-up./ Her doctor comments that she has gained quite a bit of weight since her last appointment./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /
<i>Perfectionism-related Match</i>	Barb works on creating music and sounds for a soundtrack./ She listens to what she created and hears every note flows together perfectly./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /
<i>Perfectionism-related Mismatch</i>	Barb works on creating music and sounds for a soundtrack./ She listens to what she created and hears not every note flows together perfectly./ She is very _{Region 1} / pleased _{Region 2} / to have done that. _{Region 3} /

Table 2
Definitions of four standard measures of reading behavior.

Time-course	Reading Measure	Definition
Early Processing	First fixation duration	The duration of the first fixation in the region of interest.
	First-pass reading time	Sum of all of the fixations within a region of interest, commencing at the onset of the first fixation and concluding when the participant's gaze moves outside the area of interest.
Later Processing	Regression path (or go-past) reading time	Sum of fixations from the time that a region is first entered until a saccade (or eye movement) crosses the right region boundary. Includes all time spent first inspecting a region, plus any time spent re-inspecting earlier portions of the text before moving on.
	Total reading time	Sum of all fixations in a region; regarded as a global measure of disruption to reading.

Table 3
Descriptive Statistics for Experiment 1.

Region	ms	Food Match	Food Mismatch	Perfectionism Match	Perfectionism Mismatch	Body Match	Body Mismatch
		M 95% CI	M 95% CI	M 95% CI	M 95% CI	M 95% CI	M 95% CI
1	FF	195 [185, 204]	189 [181, 198]	194 [184, 204]	197 [189, 206]	185 [177, 194]	186 [178, 195]
	FP	320 [298, 341]	339 [313, 366]	352 [317, 387]	346 [317, 375]	318 [298, 339]	320 [298, 342]
	RP	347 [320, 374]	376 [337, 415]	395 [347, 442]	384 [341, 428]	352 [320, 385]	370 [323, 418]
	TT	369 [342, 397]	405 [371, 440]	385 [353, 418]	409 [380, 439]	354 [328, 380]	381 [355, 408]
2	FF	198 [190, 206]	197 [189, 205]	194 [186, 201]	199 [192, 207]	192 [184, 200]	194 [186, 202]
	FP	225 [212, 239]	227 [214, 239]	226 [214, 237]	228 [216, 241]	223 [210, 236]	217 [205, 228]
	RP	315 [283, 348]	330 [296, 364]	358 [318, 398]	353 [313, 392]	320 [290, 349]	346 [300, 391]
	TT	283 [265, 302]	319 [292, 346]	297 [273, 320]	346 [319, 373]	281 [259, 303]	325 [301, 350]
3	FF	218 [209, 227]	225 [215, 234]	216 [206, 226]	220 [211, 229]	217 [207, 227]	216 [208, 223]
	FP	586 [543, 628]	586 [542, 630]	552 [508, 597]	599 [552, 646]	586 [539, 633]	589 [547, 631]
	RP	1006 [893, 1120]	1218 [1096, 1339]	1058 [925, 1192]	1480 [1326, 1634]	931 [843, 1018]	1304 [1154, 1454]
	TT	681 [634, 727]	717 [668, 767]	657 [601, 713]	767 [713, 820]	671 [621, 721]	756 [701, 812]

Notes. ms = Measure in milliseconds; FF = First fixation; FP = First-pass; RP = Regression Path; TT = Total Reading Time

Table 4
ANOVA results for Experiment 1.

Region	Match		Dimension		Match x Dimension	
	<i>F1</i>	<i>F2</i>	<i>F1</i>	<i>F2</i>	<i>F1</i>	<i>F2</i>
Region 1						
First fixation	.01	.01	6.53**	2.76+	1.00	2.17
First-pass	.48	1.70	4.83**	1.85	.78	.40
Reg path	.66	1.73	2.15	.45	.72	.65
Total time	11.61***	13.66***	4.51**	2.58+	.16	.17
Region 2						
First fixation	.96	3.17+	1.46	1.29	.60	1.59
First-pass	.03	.06	1.03	1.16	.45	.21
Reg path	.80	.37	2.56+	3.87*	.66	.93
Total time	27.05***	28.86***	2.94+	2.63+	.24	.52
Region 3						
First fixation	.91	.47	1.15	.94	.61	.22
First-pass	1.38	.56	.42	1.37	1.92	.68
Reg path	77.76***	41.38***	9.18***	6.28**	3.79*	2.63+
Total time	38.25***	51.46***	.61	.87	3.73*	1.46

Notes. *** $p < .001$; ** $p < .01$; * $p < .05$; + $p < .10$

Table 5a

Enter Multiple Regression Model: EDE-Q 6.0 Experiment 1 (N = 90).

Model	B	95% CI for B
Constant		1.44, 1.94
Total Reading mm Region 1 Perfectionism	-.23***	-.004, -.000
First-pass mm Region 2 Perfectionism	.23**	.000, .003
Regression path mm Region 2 Body	.21*	.000, .007

Notes. mm = Mismatch effect; $R^2 = .17$, * $p = .031$; ** $p = .026$; *** $p = .025$

Table 5b

Enter Multiple Regression Model: BMI Experiment 1 (N = 90).

Model	B	95% CI for B
Constant		21.97, 23.54
Total Reading mm Region 1 Perfectionism	-.29*	-.01, -.002

Notes. mm = Mismatch effect; $R^2 = .08$, * $p = .006$

Table 6
Descriptive Statistics for Experiment 2.

Region	ms	Food Match M 95% CI	Food Mismatch M 95% CI	Perfectionism Match M 95% CI	Perfectionism Mismatch M 95% CI	Body Match M 95% CI	Body Mismatch M 95% CI
1	FF	190 [180, 200]	189 [178, 200]	185 [175, 195]	196 [184, 208]	183 [175, 191]	190 [180, 200]
	FP	316 [295, 338]	320 [297, 343]	341 [311, 370]	323 [301, 345]	323 [296, 351]	319 [292, 346]
	RP	330 [306, 354]	331 [306, 356]	364 [330, 398]	351 [323, 379]	331 [302, 359]	338 [306, 371]
	TT	341 [317, 366]	373 [344, 403]	365 [336, 394]	412 [377, 446]	341 [314, 368]	394 [359, 430]
2	FF	194 [187, 201]	193 [185, 201]	198 [188, 208]	189 [180, 198]	184 [177, 192]	194 [186, 203]
	FP	221 [210, 232]	221 [208, 233]	224 [209, 238]	219 [206, 233]	210 [198, 222]	227 [213, 240]
	RP	306 [277, 335]	334 [295, 374]	317 [291, 344]	309 [280, 337]	304 [279, 330]	324 [292, 357]
	TT	280 [261, 300]	310 [284, 336]	285 [263, 307]	331 [303, 359]	274 [254, 293]	370 [309, 431]
3	FF	213 [203, 222]	214 [206, 222]	209 [201, 217]	219 [210, 228]	214 [206, 223]	214 [205, 223]
	FP	549 [504, 593]	562 [518, 605]	574 [529, 619]	554 [511, 597]	569 [519, 618]	581 [536, 625]
	RP	840 [750, 930]	1126 [938, 1313]	936 [826, 1047]	1469 [1267, 1670]	846 [743, 950]	1299 [1117, 1482]
	TT	637 [583, 690]	712 [647, 778]	667 [615, 720]	758 [695, 820]	662 [600, 723]	799 [722, 875]

Notes. ms = Measure in milliseconds; FF = First fixation; FP = First-pass; RP = Regression path; TT = Total Reading Time

Table 7
ANOVA results for Experiment 2.

Region	Match		Dimension		Match x Dimension	
	F1	F2	F1	F2	F1	F2
Region 1						
First fixation	2.99+	2.72	1.10	.79	1.31	2.26
First-pass	1.35	.00	1.72	1.15	.94	.25
Reg path	.04	.16	4.05**	2.91+	.58	.48
Total time	30.19***	30.40***	5.11**	2.46+	.62	.40
Region 2						
First fixation	.00	.28	.96	2.09	4.06**	1.71
First-pass	1.04	.74	.15	.40	2.13	1.09
Reg path	2.55	1.80	.17	.40	1.27	.73
Total time	17.82***	27.38***	1.90	1.22	3.75*	2.33
Region 3						
First fixation	1.73	2.45	.02	.06	1.51	1.65
First-pass	.03	.00	1.10	.27	.76	.32
Reg path	78.81***	69.82***	7.78***	8.09***	2.96+	2.09
Total time	63.69***	63.54***	5.50**	2.19+	1.81	.52

Notes. *** $p < .001$; ** $p < .01$; * $p < .05$; + $p < .10$

Table 8a

Enter Multiple Regression Model: EDE-Q 6.0 Experiment 2 (N = 90).

Model	B	95% CI for B
Constant		1.50, 2.02
First fixation mm Region 3 Perfectionism	.26*	.002, .014

Notes. $R^2 = .07$; * $p = .014$

Table 8b

Enter Multiple Regression Model: BMI Experiment 2 (N =90).

Model	B	95% CI for B
Constant		22.15, 23.60
Total RT mm Region 3 Perfectionism	-.26**	-.01, -.001
First fixation mm Region 2 Body	-.21*	-.03, -.001

Notes. $R^2 = .11$; * $p = .038$; ** $p = .014$

1

Supplement

Scenario Type	Example
<i>Food-related Match</i>	Lucy/You love(s) to cook and bake for friends. She/You decide(s) to make some brownies one evening and end(s) up eating them all. She/You feel(s) rotten because of that situation.
<i>Food-related Mismatch</i>	Lucy/You love(s) to cook and bake for friends. She/You decide(s) to make some brownies one evening and decide(s) to refrain from eating them. She/You feel(s) rotten because of that situation.
<i>Body image-related Match</i>	Lucy is/You are spending time with her/your friend. Lucy/You can feel the rolls of her/your sides hanging out over her/your trousers. She/You feel(s) rotten because of that situation.
<i>Body image-related Mismatch</i>	Lucy is/You are spending time with her/your friend. Lucy/You can feel her/your fit sides inside her/your nicely loose trousers. She/You feel(s) rotten because of that situation.
<i>Perfectionism-related Match</i>	Lucy/You head(s) to a conference. Right before she/you walk(s) into the conference, she/you realise(s) that she is/you are going to be quite late. She/You feel(s) rotten because of that situation.
<i>Perfectionism-related Mismatch</i>	Lucy/You heads to a conference. Right before she/you walk(s) into the conference, she/you realise(s) that she is/you are going to be a bit early. She/You feel(s) rotten because of that situation.

2

3

Materials Pre-tests

The experimental materials were extensively pre-tested to determine that each scenario’s three dimensions were interpreted by participants as at least 75% uniquely related to the intended dimension (food-, perfectionism-, or body-related), and appropriate match (match vs mismatch).

Dimensions Pre-test

Firstly, to create a set of 36 materials clearly representing each dimension (food, perfectionism, and body), 18 native English-speaking females between 19 and 36 years old ($M = 26.67$, $SD = 4.67$) read one version of 49 initial materials. For each material, the participant was asked to indicate, on a 100-point sliding scale, from 0% (not at all about x) to 100% (absolutely about x), the extent to which the scenario was about: food, perfectionism, and/or the body (see Figure 1).

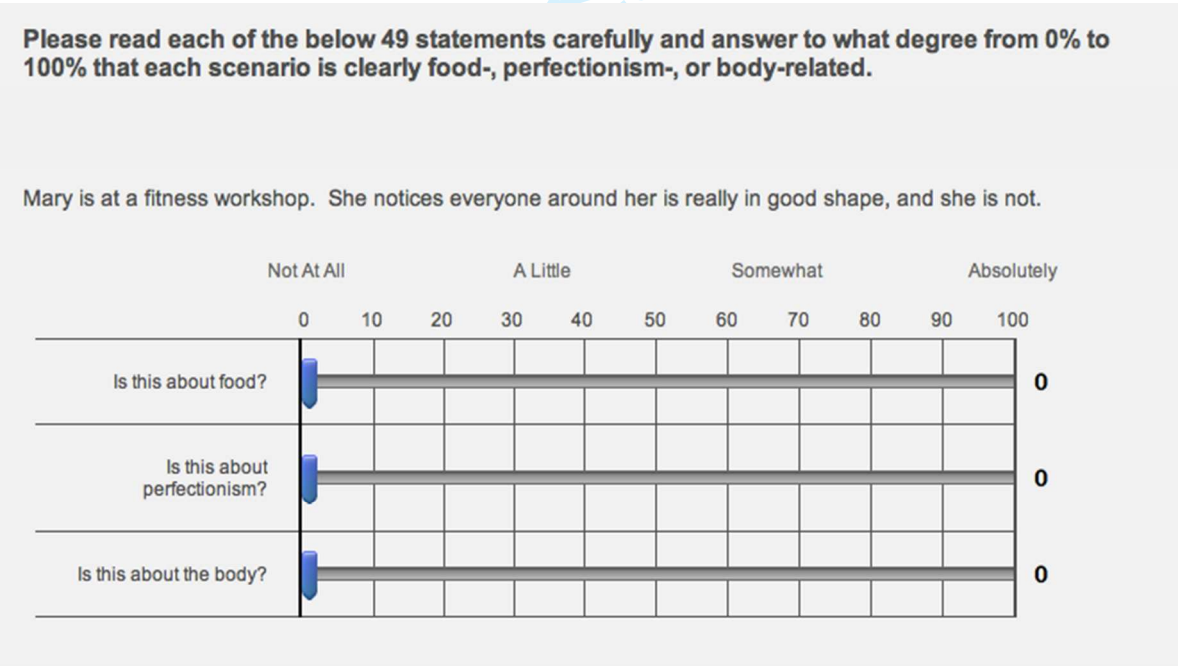


Figure 1. Dimensions pre-test screenshot example.

The 36 materials that were most highly rated (i.e., rated as closest to 100% “about food” in the food condition, etc.) and as exclusively related to the intended dimension (food-,

perfectionism-, or body-related) were chosen out of the initial 49 that were tested. The 36 top-rated materials all scored over 75% in the intended dimension (see Figure 2). Paired samples *t*-tests compared each dimension to the others (food vs. perfectionism vs. body) for each question (i.e., Q1: “*Is this about food?*” Q2: “*Is this about perfectionism?*” Q3: “*Is this about the body?*”), and confirmed that each of the three dimensions significantly represented the intended dimension ($ps < 0.01$).

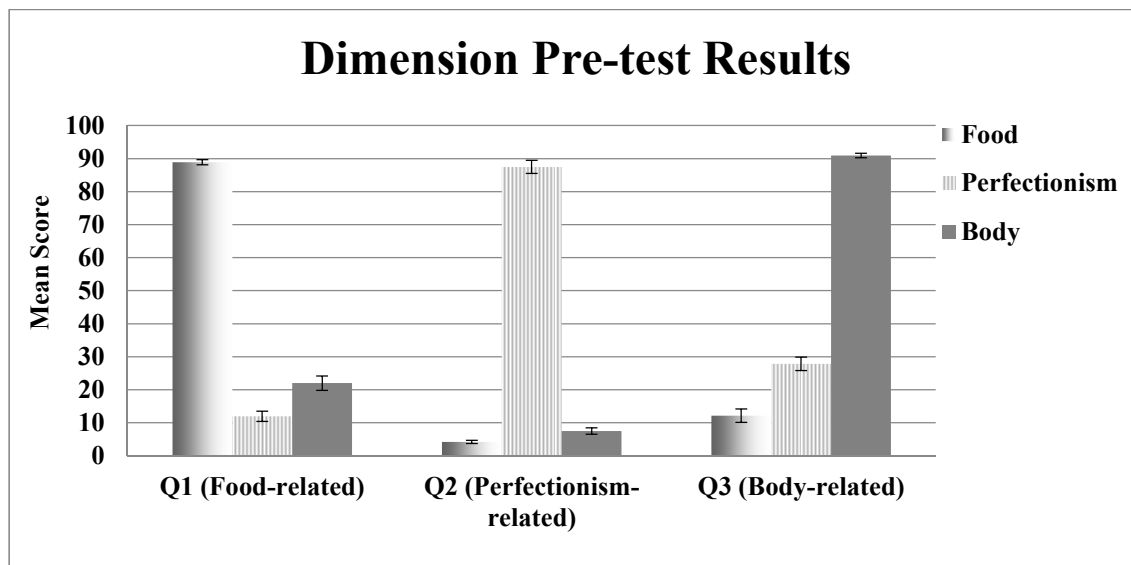


Figure 2. Mean ratings given to materials in each dimension (error bars represent *SE*).

Match/Mismatch Pre-test

These 36 scenarios were then subjected to a second pre-test in order to determine that the “match” or “mismatch” emotional responses in the target sentences did actually match or mismatch with participants’ expectations. In this pre-test, three counterbalanced lists were created such that each participant saw both the “match” and the “mismatch” version of 36 scenarios in one of the three dimensions (food-, perfectionism-, or body-related). Participants were 21 native English-speaking females between 24 and 37 years old ($M = 30.57$, $SD = 3.88$). They were instructed to carefully read both versions of one dimension of each item, to choose

the version in which the reaction of the character was more unexpected, and to write why the character’s response in the scenario she picked was unexpected (see Figure 3).

Results showed that only eight of the 216 scenarios (36 items * six conditions) had more than one participant selecting an incorrect choice (i.e., choosing the “match” condition rather than the “mismatch” condition as the scenario that is unexpected). These eight scenarios were thus slightly altered according to the feedback from participants, in order to create a final set of 36 “match” and “mismatch” version in each condition (36 food-, 36 perfectionism-, and 36 body-related scenarios).

Please read each of the below 36 scenarios carefully, which each have two versions of a situation.

1. Click on which of the two scenarios in each question is NOT how you expected the character to respond toward the situation.

2. Fill in a brief explanation of WHY that scenario’s character response was NOT what you expected, under the unexpected scenario for each.

There are no trick questions - please answer according to what you obviously see in the scenario in your opinion.

Choose the scenario you feel that the character’s response is NOT what you expected.
Please write why you felt that the response was unexpected:

☐ Barb stops by the shop on her way home from work. She gets a large tub of ice cream, and goes home and eats a small portion. She is very pleased to have done that.

☐ Barb stops by the shop on her way home from work. She gets a large tub of ice cream, and goes home and eats the whole thing. She is very pleased to have done that.

Figure 3. Match/Mismatch pre-test screenshot example.