LATENT CLASS ANALYSIS OF EMOTIONS EXPERIENCED DURING COMPULSIVE HAIR-PULLING EPISODES

by

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ABSTRACT

The present study sought to identify subgroups among participants who experienced compulsive hair-pulling episodes. Data was collected from participants in an online treatment program for trichotillomania (TTM; N=1,728). A latent class analysis was used to identify patterns of emotions associated with compulsive hair-pulling episodes. Six classes of participants were found. These six classes reflected three predominant themes, one of which differs notably from contemporary conceptualizations of TTM, and all three themes have direct implications for personalizing treatment to individualized symptom presentations. Participant classes did not show substantial differences on clinical measures, and accordingly this work highlights unique symptom patterns that are not readily identified by existing clinical measures.

I. INTRODUCTION

Up to 2% of the population experiences trichotillomania (TTM), which falls under the broader category of body-focused repetitive behaviors (BFRBs; Grant & Chamberlain, 2016). TTM is classified within the obsessive-compulsive and related disorders category in the DSM-5 (American Psychiatric Association, 2013). TTM is characterized by a compulsive and recurrent urge to pull one's own hair from a given location on the body, with common locations being the scalp, eyebrows, and eyelashes (Güleç, 2020). Physical deformities can result, such as bald patches and skin lesions. As a result, TTM often results in substantial functional impairment in social domains and self-esteem (Duke et al., 2009). Comorbidity with either other BFRBs (such as compulsive skin-picking) and emotional disorders (such as depression and anxiety), is extremely common (Grant, 2019).

Empirically supported interventions for TTM include cognitive behavioral therapy (CBT) and pharmacotherapy (McGuire et al., 2014; Bloch et al., 2007). Cognitive behavioral approaches are included as first-line approaches (Murphy et al., 2013), with predominant focus on emotional reinforcement patterns similar to those treated using the Comprehensive Behavioral Intervention for Tics (C-BIT). C-BIT has two major components that are used to address tics and parallel treatments used for TTM or BFRBs. Specifically, awareness training and habit reversal training (HRT) are the primary mediums employed for this method (Fründt, Woods, & Ganos, 2017). Awareness training focuses on identifying premonitory urges that precede hair-pulling, and HRT focuses on creating a physical action (competing response) that is incompatible with the undesired hair-pulling behavior (Morris et al., 2013). Additionally, acceptance

and commitment therapy (ACT) has also shown promise for TTM by using mindfulness and emotional acceptance to target maladaptive symptom reinforcement patterns (Snorrason, Berlin, & Lee, 2015).

While contemporary interventions are effective, symptom response often remains incomplete. A possible reason for suboptimal treatment response is symptom heterogeneity, where patient subgroups may have different symptom patterns that are not targeted by contemporary interventions. Relatively few studies have evaluated symptom heterogeneity in TTM. Recently, Grant et al. (2020) conducted a mixture modeling study on hair-pulling and skin-picking with the main outcome measure being latent classes. Outcome measures included Milwaukee Inventory for Subtypes of Trichotillomania (MIST-A-R) and the Massachusetts General Hospital Hair Pulling Scale (MGH-HPS). Other modeled variables included impairment, perceived emotion regulation, distress, perfectionism, and comorbidity. For TTM, three subtypes were identified in relation to these broad-level characteristics, and results found some sensory or automatic vs. focused differences. While these subtypes inform typical clinical outcomes, episodic and person-level analysis via the present study account for detailed, emotional and behavioral outcomes that further differentiate class typology. Lochner et al. (2019) also evaluated heterogeneity through the lens of comorbidity patterns, and found that among people with TTM, only 20.7% presented with no comorbid conditions, while 16.1% had comorbid major depressive disorder (MDD) and 63.2% presented with multiple comorbid disorders.

While research into TTM heterogeneity has generated preliminary results at the diagnostic level, research has not evaluated heterogeneity in emotional response patterns

during CBT treatment. Prior work in TTM has primarily considered two types of motivations for pulling (Franklin, Zagrabbe, & Benavides, 2011). The first is a more automatic process, where patients are largely unaware of pulling until after several hairs have been removed. The other is a more focused process, where pulling serves to modify undesired emotions. Given that CBT for TTM relies on a model of reinforcement, it is critical to evaluate whether this model holds for all patients, or whether there may be further subsets who have unexpected reinforcement patterns that prevent treatment response.

Two major barriers have impeded this approach. First, gathering data at the level of individual hair-pulling episodes is very difficult. Second, analytic approaches to parse apart heterogeneity often require very large sample sizes (Nylund, Asparouhov, & Muthén, 2007), which are often unattainable in clinical research. To address these limitations, creative approaches are needed.

With regard to data collection, the emergence of internet-based interventions allows for both convenient and cost-effective treatment (Sander, Rausch, & Baumeister, 2016), and also facilitates real-time data collection in ways that are generally inaccessible during conventional treatment. With regard to analytic approaches, continued developments in unsupervised machine learning allow for the identification of empirical subgroups of patients, while also increasing model robustness when working with sample sizes common in clinical research (Brusco, Shireman, & Steinley, 2017).

Taken together, these novel approaches inform the primary aim of this paper, which is to understand how compulsive hair-pulling affects emotional response. This question underpins CBT for TTM, as treatment is specifically designed to address

emotional reinforcement. If nontraditional emotional reinforcement patterns are identified, this approach can provide information to further tailor treatment to patient subgroups in a personalized medicine approach. To date, no studies have directly addressed this question in a large treatment-seeking sample. In response, data used was collected from an online treatment program that assessed emotional responses to hair-pulling. Patient subgroups were identified using latent class analysis (LCA), an approach to unsupervised machine learning that relies on mixture modeling. It was hypothesized that multiple patient subgroups would be identified by LCA, which would show varying emotional reinforcement patterns that could inform treatment selection.

II. METHOD

Participants

Data were collected from participants who enrolled in an online treatment program for compulsive hair-pulling behavior (stoppulling.com; N=1,728). Among participants, 93.7% identified as female, which is consistent with observed gender distributions in TTM (Stein et al., 2010). With regard to age, 18.3% were ages 12-18, 16.7% were ages 19-24, 23.6% were ages 25-30, 22.8% were ages 31-40, 11.4% of participants were ages 41-50, 4.0% were ages 51-60, and 3.2% reported that they did not fall into one of these age categories. With regard to race/ethnicity, 87.6% identified as Caucasian, 3.2% identified as Asian, 2.4% identified as Hispanic, 1.8% identified as African American, 0.1% identified as Pacific Islander, and 4.9% identified as "other." Study data were de-identified by the online treatment program, and approval for research use of the data was granted by the Texas State University Institutional Review Board (IRB).

Materials

The online treatment website used by participants relied on a CBT model for intervention. It provided interactive self-help for compulsive hair-pulling, including psychoeducation as well as core elements of awareness training and habit reversal training. It also provided an online recording system where participants could monitor situations and emotions that were associated with hair-pulling episodes (Mouton-Odum et al., 2006). At the outset of treatment, participants also completed the Massachusetts General Hospital Hairpulling Scale (MGH-HPS, Keuthen et al., 1995). The MGH-HPS is a seven-item measure that assesses TTM symptom severity as well as phenomenological

aspects (distress and perceived control over hair-pulling behavior) in the past week. Reliability and factor structure of the MGH-HPS has been found to be acceptable in previous research (Keuthen et al., 2007).

Procedure

During the online treatment program, participants were instructed to record information when they experienced hair-pulling episodes. They selected among a list of possible emotions they experienced before and after the episode (a list of emotions monitored can be seen in Figure 1). For the purposes of analysis, if a person experienced a specific emotion during hair-pulling episodes during any point of treatment, it was considered to be an emotion that they experienced during episodes. Emotions were coded so that a value of one represented an answer of yes (feeling was present) and a value of zero represented an answer of no (feeling was not present). Participants also recorded situational and behavioral aspects the same day as the pulling episode occurred and whether they changed with hair-pulling episodes (see Table 2 for detail on recorded covariates).

Analytic Plan

To determine the number of participant subgroups based on emotions experienced during hair-pulling episodes, LCA was employed. LCA assumes that an unobserved variable is a cause of subgroup differences in the observed variables. In the present study, this would mean that the model assumes an unobserved latent variable differentiates emotions experienced before and after hair-pulling episodes.

Procedures for LCA followed recommendations suggested by Masyn (2013). First, a 1-class model was fit to the data, which served as a comparison for subsequent

models. Then, a 2-class model was compared to a 1-class model to see if model fit was improved. Then, a 3-class model was compared to the 2-class model, model comparisons continued in this fashion until the Bayesian Information Criterion (BIC) for the model did not reflect improved fit. A BIC difference of ≥ 10 is conventionally used to determine whether model fit shows improvement relative to a comparison model, which reflects a 150:1 support for the improved model (Kass & Raftery, 1995). Models were implemented using Mplus version 8 (Muthén & Muthén, 2017). Entropy was utilized to evaluate the quality of class separation and signify confidence in classification. Entropy ranges from zero to one, and values of .40, .60, and .80 are associated with low, medium, and high levels of class separation respectively (Clark & Muthén, 2009). Once classes were identified based on emotional response patterns, the classes were related to behavioral, cognitive, clinical, and situational covariates. These estimates were produced via manual three-step model estimation. Manual three-step estimation was used to connect qualitative descriptors to classes (Asparouhov & Muthén, 2014).

III. RESULTS

Results found that a 6-class model best characterized the data (see Table 1 for details on BIC comparisons across models). Class differentiation in the 6-class model was strong (entropy=.84). Frequency of emotions experienced by participants in each class can be seen in Figure 1 (with zero reflecting that no responders in a specific class reported a specific emotion during treatment, and one being all participants in a specific class reported a specific emotion during treatment). Overall, four of the classes reflected more conventional reinforcement patterns associated with TTM, including some emotional relief associated with hair-pulling but also increases in emotions related to frustration and shame. These classes were predominantly differentiated by the overall frequency of emotional activation (some showed higher levels of emotional response than others). Taken together, these classes accounted for 73.2% of the sample. A fifth class (7.8% of the sample) showed little reinforcement in response to hair-pulling, along with significant emotional activation across a wide range of emotions. In contrast, a sixth class (18.9% of the sample) showed very little emotional activation in the presence of hair-pulling episodes. Of note, a common observation across all six classes was that satisfaction levels were higher after hair-pulling episodes relative to before the episodes.

Differentiation Among Classes Reflecting Traditional TTM Reinforcement Patterns

Among the first four classes of participants, a number of specific differences were observed in addition to overall frequency of emotional activation. Class 1 was the most common class of people who exhibited hair-pulling, and reflected less frequent reports of anxiousness and worry after pulling compared to before, but increases in reports in guilt and irritation after pulling. Class 2 showed a similar pattern relative to Class 1 but with

increased variability, where the high-frequency emotions were similar in response rate to Class 1 but the low-frequency emotions were lower relative to Class 2. By contrast, Class 3 showed less variability and lower overall emotional reporting (though still substantially more than observed in Class 6), while Class 4 showed more variability than Class 3 but less than Class 2.

Differentiation Among Classes of Classes Reflecting Unexpected TTM Reinforcement Patterns

Participants in Class 5 showed emotional arousal across a broad array of emotions. However, the emotions experienced often showed little change in reported frequency following hair-pulling episodes. Notable emotional changes in response to hair-pulling episodes included reduction in being afraid and increases in reports of irritation, anger, and feeling overwhelmed. In contrast, participants in Class 6 showed low rates of emotional arousal before hair-pulling episodes. This left little room for emotional reinforcement following episodes, though some reductions in anxiety, fear, and guilt after hair-pulling were reported.

Covariates of Empirically Derived Classes

Participant classes that were established by emotional response patterns also varied across behavioral, cognitive, clinical, and situational covariates. Overall, classes that showed higher frequency of emotional activation showed higher rates of endorsement on behavioral, cognitive, and situational covariates. With regard to behavioral covariates, greater differentiation across classes was observed for running hair/root along face/mouth as well as biting/eating hair and pulling the root off of the hair. For location of pulling episodes, greater differentiation across classes was observed

for pulling in the car and bathroom relative to pulling in the bedroom and living room. Considering time of day of pulling episodes, participants in all classes frequently reported hair-pulling during waking hours. Differentiation was predominantly observed in the midnight-six AM time range, where increased frequency of overall emotion was associated with increased frequency of pulling during this time period. Of note, Class 2 showed very low frequency reporting for the behavior of feeling for a thick or coarse hair and for having a lack of thoughts associated with episodes (i.e., they rarely associated hair-pulling episodes with a lack of cognition). Surprisingly, the classes showed little differentiation on clinical measurements, as assessed by the MGH-HPS.

IV. DISCUSSION

This study was the first to identify empirical subgroups of compulsive hair-pulling at the level of individual hair-pulling episodes. Prior research has looked at clustering of patient groups based on comorbidity and overall phenomenology (Grant et al., 2020; Lochner et al., 2019), and this study complements this body of research. Results from this study suggest that there is clear differentiation between types of hair-pulling behavior with a substantial subgroup of participants whose symptoms do not conform to contemporary conceptualizations of TTM and may be less likely to respond to treatment.

Identified Classes Based on Emotional Experiences Associated with Hair-Pulling

Across the six identified classes, there were three major patterns of emotions associated with hair-pulling. Classes 1 through 4 reflected a pattern commonly seen in clinical practice, while Classes 5 and 6 showed distinct patterns. Classes 1 through 4 showed emotional patterns that reflected positive reinforcement associated with hair-pulling, but also guilt and shame experienced following hair-pulling episodes. Prior work in this area has identified reinforcement (e.g., pulling to relieve anxiety) for pulling in individuals with more severe symptoms (Woods et al., 2006). The classes varied most notably with regard to frequency of endorsement of emotions associated with pulling, with various classes showing more/less frequent endorsement than others. Classes 1 and 2 in particular tracked each other with regard to overall patterns, though some differences between these classes were observed. These differences included Class 1 feeling less frequently afraid after pulling, while Class 2 was more variable in general and experienced “lower lows” with regard to frequency of various emotions. Similarly,

Classes 3 and 4 also tracked each other, except for Class 3 feeling less satisfied and more bored after pulling.

Notably, across all six classes there was an increase in guilt after pulling, while reductions in anxiety following hair-pulling were minimal or incomplete. While anxiety is commonly comorbid with TTM (Grant et al., 2017), this suggests TTM as having emotional processes independent of anxiety. Also present across all six classes was an increase in feeling satisfied after pulling. This suggests that satisfaction from pulling is common in all pulling behaviors, regardless of specific profile or emotional differences (e.g., someone can still be anxious afterwards but feel satisfied). This is similar to what is seen traditionally in clinical practice and is a commonly reported reinforcer for pulling (Walther et al., 2010). Further implications from this finding is the possible case for reinstating a similar DSM criterion to "pleasure, gratification, or relief…" which was dropped from DSM-4 and is no longer a diagnostic criterion in DSM-5, such as listing the feeling of being satisfied after hair is removed (American Psychiatric Association, 2000; American Psychiatric Association, 2013).

Class 5 (the highly-aroused class) particularly stood out for the high rates of endorsement of many emotions, and also for its relative lack of change in endorsement of emotions following hair-pulling episodes. Class 5 accounted for the lowest percentage of the overall sample, and reflected pullers who were highly emotional. Participants in Class 5 were almost entirely elevated on emotional levels after the behavior occurred. However, they rarely experienced relief of these emotions due to hair-pulling. It is possible that these participants are seeking emotional relief for pulling and are not receiving much reinforcement from pulling aside from feeling some satisfaction when the

hair was removed, reflecting an emotionally dysregulated process. If this is the case, interventions that specifically target emotional dysregulation may be indicated for this class, such as dialectical behavioral therapy (DBT; Linehan, 1993). It is also possible that this class is not actively seeking broad emotion regulation through hair-pulling, but instead are more highly aware of the hair-pulling behavior (as reflected by their highest endorsement of sensory behaviors such as running the hair along the mouth and biting/eating). Another possible pattern among this group is that it reflects goal-directed sensory stimulation, which may benefit from treatments targeted towards sensory awareness and management such as acceptance and commitment therapy.

In contrast, participants in Class 6 associated few emotions with hair-pulling. It is possible that this group shows relatively little situational awareness when pulling, and may particularly benefit from extended awareness training that is specifically targeted to hair-pulling. In particular, environmental reminders to be aware of pulling may be especially helpful if they show lower emotional awareness (e.g., post-it notes placed in key locations; Franklin & Tolin, 2007). It is also possible that they may be experiencing low emotional activation overall. This could be indicative of depression, which also shows substantial comorbidity with TTM (Grant, 2019).

Consideration of Covariates

Among behavioral, cognitive, and situational covariates, several patterns were observed across classes. Overall, classes with higher emotional endorsement rates were usually associated with higher endorsement rates on behavioral, cognitive, and situational covariates, though this relationship was not found for clinical covariates. Class 5 had the highest endorsement for all domains (behaviors, thoughts, location, and time), but

accounted for the lowest percentage of the overall sample. Some of the behaviors that were more uniquely endorsed by participants in Class 5 also reflected more overt or extreme behaviors (e.g., biting/eating hair, pulling in the middle of the night), and research into trichophagia may be uniquely relevant for those who fall into this group (Grant & Odlaug, 2008). By contrast, Class 6 was also unique with lower frequency of endorsement of most behaviors and thoughts. Classes 2 and 6 were very likely to report associate "nothing really" when considering thoughts that can go along with some hair-pulling episodes; especially given the low emotional endorsement rates in Class 6, this behavior may reflect with lack of awareness or possible depression-related interference in cognition associated with hair-pulling episodes. Sleep interference may also be particularly relevant for participants in multiple classes who report pulling hair after midnight. For these participants, behavioral sleep interventions such as cognitive behavioral therapy for insomnia (Perlis et al., 2006) could be indicated, though causal implications of these findings remain unclear (whether late-night hair pulling causes sleep interference, vice versa, or perhaps there is a mutually reciprocal relationship between the two).

Notable, minimal differences were observed with regard to the clinical measure employed, the MGH-HPS. It is possible that the MGH-HPS does well to assess symptoms within the clinical context, but does not fully link to everyday patient experiences. Specifically, emotional response patterns may add notable information beyond the clinical domains of symptom frequency, resistance, and control. Measurement at the level of individual hair-pulling episodes (e.g., via digital phenotyping; Insel, 2018)

can provide further insight into clinical measurement and treatment, and may be merited for integration into future TTM assessment protocols.

This study had several limitations. Participants did not receive semistructured assessment, and as a result it cannot be confirmed that they reflect a clinical sample. However, many people experience compulsive hair-pulling episodes that do not meet full diagnostic criteria but merit intervention (Houghton et al., 2015). Also with regard to the present sample representing real-world clinical practice, a majority of participants were Caucasian, and future research would benefit from increased participant diversity. Additionally, emotions were measured across an entire treatment program, but the relationship between intervention and emotional change was not observed. It is possible that following intervention, emotional patterns associated with hair-pulling may have changed, which merits investigation in future research. Finally, because a naturalistic observational sample was used, limits to data collection were observed. Participants varied in how frequently they reported hair-pulling episodes, and emotions were recorded in dichotomous format. Alternative data collection methods could further standardize time points collected and increase precision of emotional measurement. Of note, participants who reported more hair-pulling episodes than others would have more chances to endorse different emotions, which could increase the chances of endorsing multiple emotions.

Overall, the approach taken by this study allows for a more precise understanding of emotional patterns associated with compulsive hair-pulling, along with personalized treatment recommendations that may improve treatment outcomes. Some participants show emotional response patterns that are consistent with seeking emotional

reinforcement, while others showed across-the-board emotional activation that did not show much emotional reinforcement from pulling, and still others do not report many emotions at all in the context of hair-pulling. Contemporary CBT often focuses on breaking reinforcement patterns with hair-pulling, and approximately 70% of participants reflected emotional patterns consistent with this model. This leaves a sizable subgroup who may need adjustments to treatment depending on what class they fall under in order to achieve improved symptom response. These adjustments may also benefit those participants whose emotional response patterns were consistent with contemporary TTM models (e.g., they appear to receive some relief from pulling, but also experience notable sleep interference and would benefit from CBT for insomnia). Taken together, these results highlight pathways to improved treatment outcomes and prevention of ineffective courses of treatment.

APPENDIX SECTION

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Table 1

Observed Values for Bayesian Information Criterion (BIC) Across Models Evaluated

Class	BIC	BIC Difference
1	90778.129	
2	82190.833	8587.296
3	80746.667	1444.166
4	80142.299	604.368
5	79827.337	314.962
6	79571.17	256.167
7	79769.3	-198.13
8	79800.669	-31.369
9	79866.012	-65.343

Note. BIC=Bayesian Information Criterion

Table 2

Behavioral, Cognitive, Clinical, and Situational Covariates

Associated with Observed Latent Classes

Qualitative Description	1	2	3	4	5	6
Behaviors						
Stroking hair before pulling	93.3%	86.8%	95.5%	86.5%	98.3%	76.7%
Feeling for a thick or coarse hair	90.9%	72.4%	0.2%	79.5%	89.6%	57.6%
Searching for a certain hair	92.2%	79.7%	93.3%	85.1%	100.0%	72.9%
Running hair/root along face/mouth	34.4%	25.9%	34.8%	20.2%	50.3%	4.5%
Bite off root	26.3%	20.5%	31.3%	16.9%	35.2%	0.8%
Eat hair/eat root	18.8%	12.0%	22.2%	13.1%	25.4%	1.7%
Pull the root off the hair	26.2%	15.1%	30.2%	17.2%	38.1%	1.9%
Thoughts						
Current life problems	84.8%	42.9%	77.2%	56.6%	95.2%	7.4%
Anger at self at pulling	85.2%	48.7%	72.7%	68.1%	87.1%	18.5%
This hair will bother me until I pull it out	74.1%	47.1%	76.6%	52.2%	90.9%	8.5%
I will only pull a few	73.1%	48.4%	78.9%	51.8%	95.9%	9.6%
Nothing really	85.0%	69.3%	0.8%	45.0%	92.0%	8.4%
Location Where Pulling						
Car	71.6%	51.3%	68.0%	57.3%	81.1%	45.1%
Bedroom	96.0%	88.5%	90.6%	91.7%	100.0%	75.7%
Living room	86.5%	77.6%	88.1%	74.4%	90.9%	65.4%
Bathroom	80.0%	68.3%	87.4%	65.4%	94.7%	50.1%
Time When Pulling						
Midnight - 6 AM	78.5%	57.9%	66.4%	61.0%	89.3%	41.2%
6 AM - Noon	99.1%	94.8%	99.1%	95.6%	99.5%	89.3%
Noon - 6 PM	100.0%	100.0%	100.0%	99.3%	100.0%	95.0%
6 PM - Midnight	100.0%	99.3%	99.5%	100.0%	100.0%	96.0%
MGH-HPS Scores						
Frequency	2.7	2.3	2.6	2.5	2.7	2.4
Resistance	2.3	2.2	2.2	2.1	2.3	2.3
Control	3.5	3.2	3.4	3.3	3.4	3.4
Model Estimated *n*[a]	406.9	284.1	190.0	385.1	134.8	327.2
Sample Proportion	23.5%	16.4%	11.0%	22.3%	7.8%	18.9%

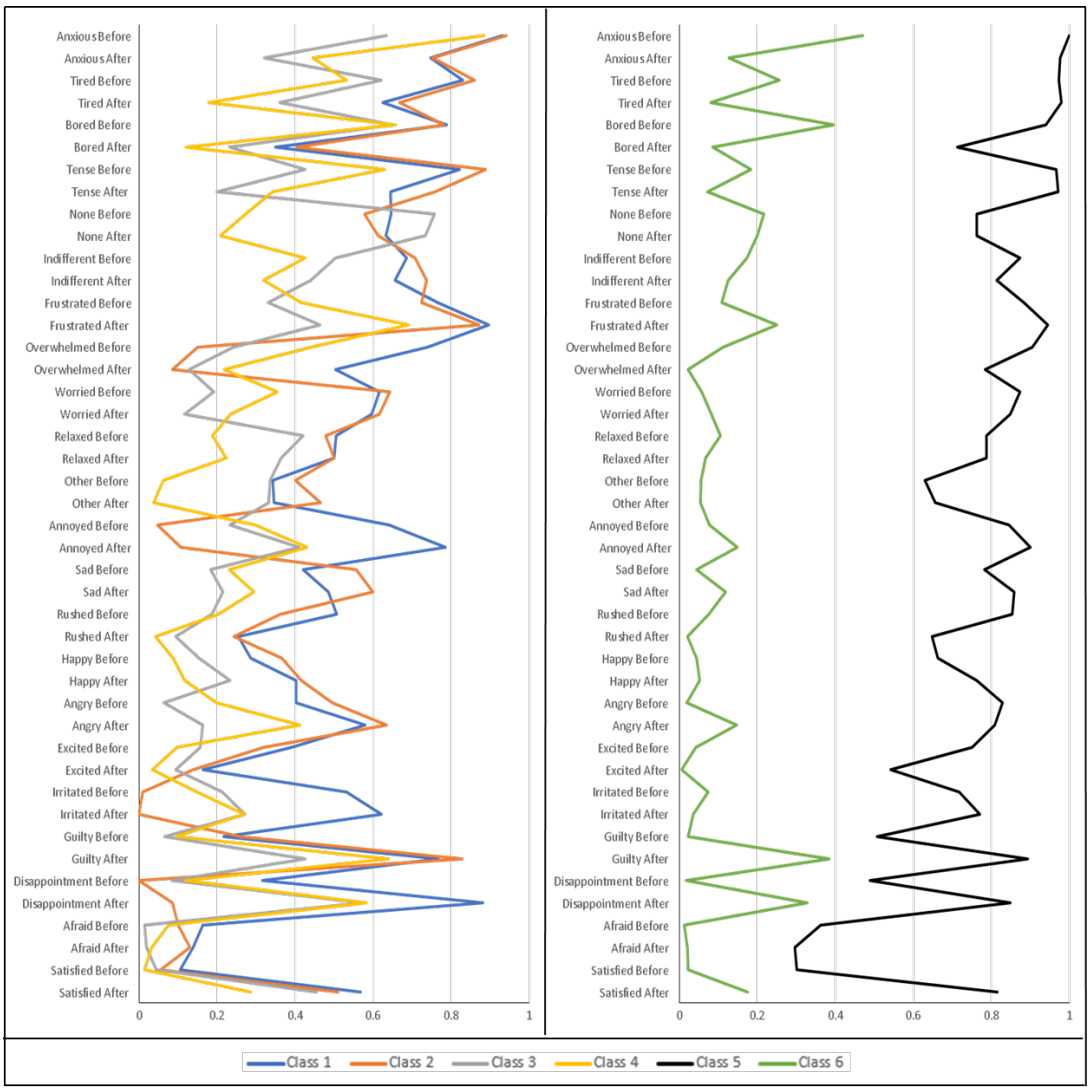

Figure 1. Probability of Endorsement of Emotions Before and After Hair-Pulling Episodes for Each Participant Class

Note. To aid in interpretation, the four classes that reflect a more traditional conceptualization of TTM are shown in the left panel, while the two classes that differ from this pattern are shown in right panel

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