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"RAGE-Control": A Game to Build Emotional Strength

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Abstract

Emotional regulation is an important skill, and some children require extra support to develop that skill. To address this need, we have built an active biofeedback videogame and incorporated the game into a cognitive behavioral therapy. Our approach requires that players simultaneously attend to a demanding task and still maintain emotional control, forcing practice and skill building in both domains concurrently. Early studies have shown that our approach improves emotional control compared with treatment as usual and has led to promising new developments of emotionally aware toys that can reach younger children.

Background

Maybe Yoda[1] is cliché, but he implored his would-be heroes to stay in control as they faced increasingly impossible situations. To be successful in his universe, physical strength did not rule the day, but the ability to be the master of your emotions was tantamount. The key skill was not just relaxation and dispassion. Action was required: Intense, directed, and without any faltering of concentration. If, in the midst of these demands, one lets his or her emotions get the best of one? Walk the paths of destruction and villainy, you would.

In early childhood, we expect that children show some levels of anger and aggression in the context of situational stress.[2,3] Although many children learn to self-regulate, some children have pathological deficits in their ability to control emotions and behaviors and therefore have significantly detrimental social and academic outcomes. Socially, children who struggle with emotional control often have poor interpersonal skills and lack peer relationships. Academically, disruptive children tend to be removed from the classroom, feeding chronic underachievement in school. As these children move through adolescence, unchecked emotional dysregulation makes kids vulnerable to other significant difficulties in later adulthood, including school dropout, underemployment, substance abuse, and antisocial behavior.[4–6]

Emotional dysregulation is a common disorder seen by clinicians, and the presence of severe emotional dysregulation disorders predicts mental health problems in adulthood.[7] Families, clinicians, and researchers are all invested in developing effective treatments, although options are limited. Existing evidence-based psychotherapy is limited in effectiveness, as these children frequently fail to engage with clinical staff or struggle to apply the skills taught in therapy in external situations.[8–10] Psychiatric medication is the other commonly used intervention. Medications can help alleviate symptoms of anger and aggression but ask the patient, family, and clinician to engage in a Faustian bargain. Patients who use these medications often face serious side effects, including weight gain and flattened affect.[11] As a result, the field needs effective and engaging behavioral interventions[12] that can be made widely available.

Intended Benefits

Neurologically, emotional regulation involves two discrete networks in the brain. The first has as a central player the amygdala, which, in the face of a stressor, can trigger a cascade that includes "flight or fight" response, which has potent physiological and behavioral ramifications. Physiologically, heart rate and respiratory rate increase, muscles become tense, and sweat glands open.[13] Behaviorally, individuals tend to follow one of two pathways. If an individual internalizes his or her feelings, the person might present as anxious or withdrawn. Conversely, one who externalizes these feelings will display outward agitation and aggression, which could take the form of shouting or outright violence.[14]

In healthy children and adults, everyday stressors do not result in the amygdala running amok. Rather, a second system that is based in the prefrontal cortex moderates the amygdalar system's response to stressors. The capacity of the prefrontal cortex for emotional self-control (i.e., the ability to modulate the primitive emotional impulses) is one example of the executive functions that are subserved by that part of the brain. Others include the ability to react quickly, to quickly inhibit a response that has been repeated many times

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(a prepotent response), to shift focus, to plan, and to triage between competing demands.

In individuals with emotional dyscontrol, the functional connections between the prefrontal and amygdalar networks are weak.[15] The idea of building emotional regulation skills by strengthening the functional connectivity between these networks through practice is an attractive alternative to using medication. Traditional biofeedback has sought to teach patients to calm this network by having them imagine themselves in a calm environment and thus lower their level of emotional arousal. Although this may reinforce emotional relaxation abilities, such skills may not transfer to more challenging real-world settings where emotional regulation is required in the context of a salient environmental stressor from which the child may not be able to or want to remove his or her focus. Developing this dual skill of keeping emotional arousal low while at the same time meeting a formidable challenge requires practice using the child's full panoply of executive functions simultaneously, including emotional regulation.

Accordingly, we predict that biofeedback strategies can be improved by repeatedly engaging a child with a graded challenge to his or her executive functions while requiring that the child keep his or her emotional arousal low at the same time. In such conditions, the neural circuits that involve the amygdala and the prefrontal cortex will be engaged simultaneously, and we hypothesize that the functional connectivity between the amygdala and the prefrontal cortex will be strengthened to develop in the child the appropriate cognitive resources to respond to challenging situations in the moment.

Regulate and Gain Emotional Control ("RAGE-Control")

Design of the game

"RAGE-Control,"[16] developed by the authors, is loosely modeled after the classic arcade game "Space Invaders."[17] In both games, the player controls a space ship that moves back and forth across the bottom of the screen. Aliens fly from the top and move downward, attacking the player's ship. Beyond this, the design of the games diverges.

Measuring emotional control. "RAGE-Control" takes the user's emotional arousal as an input. If the emotional arousal goes too high, the ship starts to fire "blanks," meaning that the user can no longer fire at the aliens. The blanks visually fall backward, instead of going up toward the aliens. The player's ship also has an animation that shows it moving about randomly, as if it is out of control. The ship remains in this state until the player regains emotional control.

Emotional control is measured through heart rate. For a seated player, heart rate is an excellent proxy for emotional arousal. One of the loudest signals of the brain releasing the neurochemicals associated with attention and concentration is an increase in heart rate.[13] Although other mechanisms can raise heart rate, such as strenuous activity, these are not factors for which we need to control with stationary players. At the beginning of the game, the player chooses a heart rate threshold for playing the game. In the clinic, a therapist provides support for choosing an appropriate threshold. When the player chooses an appropriate threshold, he or she must accomplish a balancing act: They must attend enough to succeed in the game, but at the same time, they must continuously apply relaxation skills to keep themselves under a threshold.

Maintaining cognitive attention and reacting quickly. In addition to using emotional arousal as input, we also changed the design of the "Space Invaders" template to include friendly ships in the game play. With only enemies in the design, players can simply continually press the fire button and develop a prepotent response, essentially playing with minimal attention only to the position of the incoming aliens. By including targets that the player has to quickly identify and avoid, we make players inhibit their prepotent response at a moment's notice, a task that requires greater cognitive attention. As players have to react as quickly to fire and to inhibit the impulse to fire, the greater degree of cognitive attention adds to the balancing act that is required of the player to stay calm while trying to maximize his or her score in the game.

Integrating "RAGE-Control" into therapy

Anger control therapy[18] (ACT) is a well-validated manualized cognitive behavioral therapy (CBT) that has been used in children with symptoms of anger and aggression. CBT itself is a form of evidence-based psychotherapy that has become common in therapists' toolkits. Although the technique has proven superior to other behavioral interventions it has replaced, CBT itself still faces challenges. Children must have the motivation to engage in therapy. Also, as the name implies, CBT relies on certain cognitive resources on the part of the child in order to be successful. Children without these resources will struggle with this therapy technique.

We adapted ACT to include use of the videogame during therapy. ACT focuses on psychoeducation of anger and aggression and identification of emotional states. Our adaptation is for five daily sessions of 30 minutes each. These

Table 1. Cognitive Behavioral Therapy Content of Anger Control Therapy with "RAGE-Control" Sessions

Session number	*CBT content*
1	*Psychoeducation and deep breathing.* Participants learn about the precipitants of their anger and aggression and are introduced the skill of deep breathing.
2	*Physiological cues of anger.* Participants began to become aware of the physiological cues that correspond with increasing anger and frustration.
3	*Progressive muscle relaxation.* Participants learn how to tense and relax muscle in their bodies in order to become more relaxed.
4	*Cognitive restructuring.* Participants learn to regulate their mood by looking for the positives in any situation.
5	*Social skills training.* Participants improve social interactions by learning to monitor their body language, tone of voice, and personal space when interacting with others.

sessions are to take place on an inpatient pediatric psychiatric unit. The main CBT content of each session is described in Table 1. However, each session ended with the child playing the "RAGE-Control" videogame. Before game play, the therapist selects a threshold heart rate that will ensure the child will have some degree of success while also having an opportunity to utilize the emotion regulation skills. During game play, children are encouraged to practice the skills from the day's session or any session before. As emotional control develops as the child explores strategies that are individually successful, the therapeutic skills are only considered a starting point. Children are encouraged to vary strategies and discover for themselves what tools help them stay in control during game play.

Emotional Manipulatives

Emotional manipulatives are our next tool developed to help even younger children learn to build emotional regulation skills. They describe physical tools that change behavior with the child's emotional state: They are emotionally responsive toys. They are designed to overcome some important limitations with "RAGE-Control." Most important is that we want to be able to work on emotional control with younger children, down to 5 years of age. Younger children may be more likely to benefit from intervention[19] because mastering emotional regulation early will not lead to the multiplicative effects of a stressed family environment, poor peer relationships, and lost academic time. A classical observation is that these children learn much differently than adults and even older children,[20] and therefore special attention must be paid in education. In particular, these children learn through exploration of the physical world and make meaning from how their actions not only affect how the world looks but by exploring changes and transformation that they can affect and how these changes fit into what the child already knows.[21,22] These children are thought to be more concrete, so making physical tools with properties that saliently reflect emotional state can help these children understand the role of their emotions.

Second, we wanted to further enhance not only emotional self-awareness, but also awareness of the emotional state of others. We want to do this in both cooperative and competitive social situations as children are expected to succeed in both. Cooperatively, we strive to build tools where a team maintaining control is essential to a meeting a common goal. As team members concentrate, their emotional arousal will go up. Other team members will have to help that person maintain control. If a team member does lose control, then the team members must remain in control themselves; escalating reactions harm the disposition of the entire team. In competitive situations, two or more individual players become worse off as they become emotionally aroused. This can happen either because the player is winning or losing. This lack of control gives the opponent an advantage, thus building in an incentive to remain in control.

Thus far we have built two emotional manipulatives: Blocks and remote control cars. Blocks can be used cooperatively and shake when any member of the team becomes dysregulated. This means that the structure the team is working on will wobble and eventually collapse, building an incentive to stay in control. We envision young children working on simple tasks like building the highest tower possible, whereas older children can face more challenge in playing deconstruction-style games, where a tower needs to stay together as individual pieces are removed. Remote control cars are used competitively. Two (or more) children race the cars, and if an individual becomes aroused, then the car will go into an uncontrollable state. During this time the car moves erratically, building the connection between it and a player who is out of control. The player needs to regain control quickly, or the opponent will gain an advantage. We are currently organizing a pilot trial of emotional manipulatives in a developmentally diverse kindergarten setting.

Research

Participants and design

Full reports of the research and results summarized here have been published elsewhere.[23,24] The study took place on the inpatient psychiatry unit at Boston Children's Hospital. We compared an experimental group ($n = 18$) with a treatment as usual group (TAU) ($n = 19$). The TAU group served as a historical control; the data were acquired from an earlier quality improvement project that used the same outcome measure collected at the same time points.

Inclusion in either group required patients be between 9 and 17 years of age, be admitted to the inpatient psychiatric service at Boston Children's Hospital, and not be expected to begin or undergo a clinically significant change (dosage change ≥ 25 percent) of a mood-stabilizing or antipsychotic medication. Patients had to demonstrate elevated level of anger and aggression evidenced by a score on the State and Trait Anger Expression Inventory—Child and Adolescent (STAXI-CA).[25] Historical quality improvement data showed that children on the unit with combined State Anger (S-A) and Trait Anger (T-A) subscale scores of 30 or above remained "stuck" or did not show measured improvements in anger over their hospitalization. Therefore patients with combined S-A and T-A scores of ≥ 30 were eligible. S-A refers to the intensity of angry feelings, whereas T-A refers to the frequency of angry feelings. Patients were excluded if they were unable to consent or had an IQ of ≤ 75. If patients were unable to be assessed 5 days after the baseline measurement on the STAXI-CA (because of discharge, for example), we did not include them in the analysis.

We measured pre- and post-intervention levels of anger using the STAXI-CA. In the intervention group, the time points for measurements were before and immediately after five sessions of therapy on 5 consecutive business days on the unit. In the TAU group, the end point was 5 business days after the first data collection. In the intervention group we also measured in-game emotional control and satisfaction and helpfulness. In-game emotional control was measured by recording patients' heart rate during game play and calculating the percentage of game play time with heart rate below the set heart rate threshold for the game. Satisfaction and helpfulness were measured using the therapeutic helpfulness questionnaire.

Results

Case illustration

Sarah was one of the patients in the "RAGE-Control" group and was the subject of an earlier case study.[23] She was

admitted to an inpatient psychiatry unit after feelings of severe depression and thoughts of harm to self and others. At the start of the study, she had a combined S-A and T-A score of 59 out of a possible 60, indicating extremely high levels of anger. At the beginning of the intervention, Sarah expressed extreme skepticism of the effectiveness of deep breathing techniques. However, after a quick tutorial on timed breathing from her therapist (P.D.) and several minutes playing the game, she demonstrated the ability to maintain the deep breathing technique throughout the game and expressed satisfaction seeing that the breathing would affect her heart rate. As her sessions continued, Sarah showed an increased ability to maintain in control throughout playing the game. In talking about her family, thoughts that were negative and avoidant at the beginning of therapy were restructured in a positive direction. Sarah enjoyed playing the videogame and demonstrated increasing success through subsequent sessions, keeping her heart rate below threshold 52 percent of the time at the first session and 85 percent at the last. Her combined S-A and T-A scores decreased to 30. It is important to remember that these gains were made after just five sessions, and per the inclusion criteria of the study, her mood-stabilizing mediations remained unchanged throughout the intervention.

Differences in anger

Compared with the TAU group, patients in the treatment intervention showed more improvement against their baseline in both S-A ($t_{27} = -2.75$, $P = 0.011$) and T-A ($t_{23} = -4.85$, $P < 0.001$). Patients in the TAU group actually showed a negligible increase in levels of anger compared with their baseline scores, whereas patients in the intervention group showed decreases. This result shows statistically significant decreases in frequency of feeling angry and a trend toward measurable reductions in anger intensity that is just over the threshold for statistical significance. The threshold for significance was set at $P = 0.01$ as the STAXI-CA has multiple subscales that were looked at as independent dimensions of improvement.[24]

Emotional control within the game

We compared the amount of time that a player stayed below threshold in the game between the first and last session in the intervention group. In the first session, players were below their heart rate threshold 46 percent (±21 percent) of the time, whereas at the last session players were below threshold 69 percent (±20 percent) of the time. The change was statistically significant ($t_{17} = -3.96$, $P < 0.001$). This result shows that patients improved control over their heart rate during game play. Because heart rate is demonstrative of the level of emotional arousal, we inferred that while playing the game players showed increased ability to keep emotional low.[24]

Satisfaction

We measured satisfaction with a 1 (not helpful) to 7 (extremely helpful) helpfulness scale. Median ratings were in the 5–6 range. Treatment compliance was high: All but one patient completed all therapy sessions. This result showed that patients were satisfied with the therapy plus videogame combination.[24]

Further Directions

There are many exciting next steps for "RAGE-Control" and the types of interactions that this game describes. We are currently in the midst of a randomized control trial that compares therapy with the game with identical therapy with a sham videogame. The sham videogame works identically to "RAGE-Control," but player emotional state is not one of the controls. This means that when a player gets emotionally aroused in the sham game, the behavior of the game does not change. We look forward to discussing these results in the near future.

As we talk with patients and families, we have better understood the need to increase the "dosage" of play and the social demands within game play. Increasing dosage means giving children more opportunities to play, not necessarily while in therapy. By creating a mobile version of the game, patients will be able to take the game home with them on small, relatively inexpensive hardware and continue to play. This will provide more opportunities for them to develop emotional control strategies that work for the patients. To further stress social situations, we have developed a multiplayer version of the game. In the multiplayer version, two players play the game as a team simultaneously. However, if either of the players goes over a threshold, then neither player can fire. Engaging socially means that players have to juggle yet another cognitive demand. A co-player who is overthreshold is interfering with the goals of the team, but rather than lose control and react angrily a player must keep in control while facilitating relaxation and attention from his or her teammate.

Finally, we strive to reach younger children. In younger demographics, we believe that we can effect more change in emotional control. However, in this group, we need to reenvision how people interact with emotional objects. Rather than confine interactions to a computer screen, we are building toys that work on the same principle. These toys will provide children rich tools to interact with their emotions and their peers and, it is hoped, see even greater gains in emotional strength.

Author Disclosure Statement

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