Journal of Contextual Behavioral Science 5 (2016) 80–88

Contents lists available at ScienceDirect

Journal of Contextual Behavioral Science

journal homepage: www.elsevier.com/locate/jcbs

Empirical research

Neurological evidence of acceptance and commitment therapy effectiveness in college-age gamblers☆

Mark R. Dixon[a,*], Alyssa N. Wilson[b], Reza Habib[a]

[a] Behavior Analysis and Therapy Program, Southern Illinois University, Carbondale, IL, United States
[b] School of Social Work, College for Public Health and Social Justice, Saint Louis University, St. Louis, MO, United States

ARTICLE INFO

Article history:
Received 25 June 2015
Received in revised form
4 April 2016
Accepted 25 April 2016

Keywords:
Disordered Gambling
Young Adults
FMRI
Slot Machine
Addiction

ABSTRACT

The present study examined the potential neurological impact of Acceptance and Commitment Therapy (ACT) delivered to college-aged disordered gamblers. A randomized control design employed 18 participants to complete two functional magnetic resonance imaging scans during which time gamblers completed a slot machine activity. Following the initial scan, ten subjects were exposed to 8 h of ACT delivered 1:1 by a therapist, and the other eight remained untreated. Using a mixed 2 (group: ACT, Control) × 2 (condition: wins, losses) × 2 (time: pre, lost) design, the self-report and behavioral aspects of the slot machine activity, in addition to the brain activation data were compared across time. Results indicated that post-treatment, disordered gamblers reported higher rates of psychological flexibility and mindfulness than control gamblers. Similarly, brain activation patterns differed significantly between groups for winning outcomes when compared to losing outcomes following treatment. These data suggest that psychological reconditioning of behavioral and neurological responses to various addictive stimuli are possible using ACT. Implications for the future of contextual control, human language, and understanding addiction are suggested.

Gambling disorder is estimated to affect 0.5–7.7% of the global population (Williams, Volberg, & Stevens, 2012), and 3–8% of adolescents and young adults (Petry, 2005; Shaffer & Hall, 2001). Gambling across the lifespan occur on a continuum, ranging from never gambled to experimenting or recreational, to frequent, excessive, or disordered (Stinchfield, Hanson, & Olson, 2006). According to the Diagnostic Statistical Manual-5, gambling disorder is indicated when 4 or more symptoms are endorsed, including loss of a significant relationship, gambling during times of distress, hiding the extent of the gambling problem, and a preoccupation with gambling related thoughts (American Psychological Association, 2013). Gambling prevalence rates continue to be higher in adolescents and young adults, including college students, as compared with adults (e.g., Derevensky & Gupta, 2000; Shaffer, 2000; Shaffer & Hall, 2001). College students, as young as 18 years of age, represent a high-risk gambling population, as 42% will engage in some form of gambling during the college years (LaBrie, Shaffer, LaPlante, & Wechsler, 2003). Although many college students do in fact gamble, only a small percentage will develop a gambling addiction (Winters, Bengston, Door, & Stinchfield, 1998).

College students may be more at risk for developing disordered gambling due to a range of socio-cultural factors. For instance, college students may have fewer financial and social resources during the collegial transition years, and may result to gambling for financial means (Arnett, 2000). Similarly, demographic variables such as gender and familial history of gambling (Oei and Raylu, 2004) and addictive behaviors more generally (Slutske et al., 2001), may also increase college students' propensities to gamble (see also King, Abrams, & Wilkinson, 2010).

Gambling may also persist as a result of stimulus control and various functions of verbal behavior (Dymond & Roche, 2010). Skinner's (1959) early work on stimulus control emphasized the rule that "*stimuli present at the moment of reinforcement produce a maximal probability that the response will be repeated*" (p 143); therefore any change in the "stimulating situation reduces the probability" of future occurrences of behavior (p. 143–144). Analyses of behavior have advanced towards conditional discriminations as the unit of analysis for functional descriptions of stimulus classes: while relating pairs of stimuli formed stimulus classes so that each stimulus could serve a common function (e.g., stimulus equivalence; Sidman, 1969, 1994). Stimulus equivalence, as a conceptualization and experimental approach, has become a useful way to understand how verbal humans learn to relate various stimuli together simply by inference (or derivation) from a

☆Author Note: This research was supported in part by a Grant from the National Center for Responsible Gaming.
* Correspondence to: Behavior Analysis and Therapy Program, Southern Illinois University, Carbondale, IL 62901, United States.
E-mail address: mdixon@siu.edu (M.R. Dixon).

http://dx.doi.org/10.1016/j.jcbs.2016.04.004
2212-1447/© 2016 Published by Elsevier Inc. on behalf of Association for Contextual Behavioral Science.

reinforcement history among other stimulus pairings (see also Dymond & Rehfeldt, 2000). Additional complexity in the analysis of derived responses is introduced by examining how a function of one stimulus can impact the functions of another stimulus without any direct training.

The concept of transformation of stimulus functions (Dougher & Markham, 1994, 1996) suggests that a training history on one member of a stimulus class (Stimulus X) will not only spread to other members of that specific class (Stimuli Y and Z), but also to another separate stimulus class (Stimuli E, F and G) if one member (not even the initially trained Stimulus X) is made equivalent to a member of the separate class (Stimulus Z is trained to be equal to Stimulus G). This transformation effect has been shown with eliciting functions (Dougher, Hamilton, Fink, & Harrington, 2007), as well as a variety of operant functions (e.g., Catania, Horne, & Lowe, 1989; Dougher, Perkins, Greenway, Koons, & Chiasson, 2002; Rehfeldt & Hayes, 1998) including applied problems such as pathological gambling (Dixon, Wilson, & Whiting, 2012; Hoon, Dymond, Jackson, & Dixon, 2008; Zlomke & Dixon, 2006).

Relational Frame Theory (RFT; Hayes, Barnes-Holmes, & Roche, 2001) expands the general notion of stimulus equivalence by its inclusion of relations between stimuli other than equal. Types of relations may include opposite, comparison, temporal, and hierarchical. Within a gambling context many such relations exist where one casino may be "better than" another, a game may pay "more than" another and the player wants to be the "opposite of" a loser when going home that evening. Over the past decade a number of studies on gambling have demonstrated that when the contingencies remain the same on various gambling options, certain learning histories may transfer or transform the participant's responding into novel situations and impact wagering, persistence or both (e.g., Dixon, Bihler, & Nastally, 2011; Dixon, Nastally, Jackson, & Habib, 2009; Dixon, Wilson, & Whiting, 2012; Hoon, Dymond, Jackson, & Dixon, 2008; Zlomke & Dixon, 2006). Relational responding and self-generated rule-following (Wilson & Dixon, 2015; Wilson & Grant, 2015) have been shown to impact response allocation across games of chance with equal pay out rates.

As the body of experimental evidence continues to grow in support of an RFT explanation as to why someone would gamble, alter responses across games, and be resistant to quitting gambling, it naturally follows that the therapeutic application of RFT (e.g., Acceptance and Commitment Therapy, ACT; Hayes, Stroshal, & Wilson, 1999/2011) may hold promise in altering established relational networks to reduce the gambling behavior of a given person. The goal of ACT is to foster *psychological flexibility*, or to "train individuals to actively and openly contact their ongoing experiences in the present moment… without defense and as it serves their chosen values" (Sandoz, Wilson, & Dufrene, 2010, p 17). Psychological flexibility is targeted through the use of six interrelated components or processes termed: acceptance, present moment focus, defusion, self as context, committed action, and values. The ACT model is a set of therapeutic techniques designed to alter the way contextual verbal relations function, in the hopes of influencing experiential avoidance. The empirical evidence in support of ACT as an effective therapeutic technique continues to expand (see Ruiz, 2012 for a review), and has been evidence of an effective treatment option for substance use disorders (e.g., Twohig, Shoenberger, & Hayes, 2007).

A few brief experimental-based ACT approaches have been employed with problem gamblers and the results appear promising. In the first investigation on ACT in a gambling context, Nastally and Dixon (2012) documented a reduction in gamblers' irrational beliefs after exposure to a brief computerized delivery of ACT. Gamblers completed a slot machine activity before and after the intervention, wherein gamblers rated how close each slot machine outcome was to a win (1= not at all close, 10= very close to a win). The intervention included a PowerPoint slide-show across ACT component, each targeted at the near-miss effect (i.e., 1 or 2 identical slot machine symbols short of a win, on a single payout line). Following ACT, all three gamblers' subjective ratings of near-miss outcomes decreased. In a related study, Whiting and Dixon (2014) assessed the extent to which acceptance and defusion (through an imaginal desensitization task) would have on gambling. Thirty gamblers were randomly assigned to complete 30 imaginal desensitization trials (either imagining slot machine gambling 30 times plus dropping quarters in a laundry machine 3 times, or imagining dropping quarters in a laundry machine 30 times plus slot machine gambling 3 times). Next, gamblers were asked to play on a slot machine for as long as they wanted to. Results showed that participants who accepted gambling images/thoughts played less than participants who did not think about gambling images/thoughts. Taken together it appears that a full therapeutic trial for pathological gamblers could be valuable using the ACT model.

If implemented successfully an ACT-based treatment for disordered gamblers could potentially make gambling less appetitive by disrupting existing relational networks between stimuli, or by creating new competing relational frames that are in contrast to prior held frames. For example, if a client tends to see gambling as an activity which allows for acquiring additional money with no effort (if-than frame), and is seen as equivalent to working a job that yields money (coordination frame), that client may find little reason to quit gambling because it is just another way to make money. However, if that client is now exposed to a therapeutic intervention which alters such relations to include relational networks targeted at larger value systems (e.g., *If I gamble, then no bills get paid; and gambling is the same as missing family time*), then the client might reduce gambling because these relational frames contain more aversive stimulus functions than before (Barnes-Holmes, Barnes-Holmes, McHugh, & Hayes, 2004; see also Hayes et al., 2001 for similar argument).

To date, therapeutic interventions for gambling have relied heavily on self-reports of gambling (e.g., Hodgins, Currie, & el-Guebaly, 2001; Petry, Weinstock, Morasco, & Ledgerwood, 2009; see also Gooding & Tarrier, 2009 for a review), with limited outcome studies focusing on direct behavioral observation. Unlike other substance use disorders, direct measures useful in detecting substance use over time (such as urine or hair samples) are not possible for gambling. While subjective reporting and reliable psychometric assessments are commonly place for gambling research, additional direct observational methods across a range of behavioral phenomenon (including physiological changes) may serve as additional measures to assess the effectiveness of interventions.

Emerging neuroimaging studies on substance use disorders have found neurological similarities between disordered gambling and other substance use (e.g., Potenza, 2008; Shah, Potenza, & Eisen, 2004) including cocaine (Wareham & Potenza, 2010), methadone and alcohol (Goldstein & Volkow, 2002), and tobacco (De Ruiter et al., 2009). Neuroimaging studies have also found differences in brain activation and functioning patterns across gambling proclivity (Habib & Dixon, 2010) and gambling outcomes (Dixon, Wilson, & Habib, 2014). For instance, Habib and Dixon (2010) subjected disordered and non-disordered gamblers to a slot machine activity. Gamblers were instructed to rate each slot machine outcome (e.g., wins, losses, and near-misses or 2 of 3 matching symbols on the payout line) during the slot machine activity. Results showed increased dopaminergic activation for non-disordered gamblers during winning trials when compared to losing trials; with increased dopaminergic activation for disordered gamblers during near-miss trials when compared to losing trials.

Gamblers subjective ratings of slot machine outcomes, however, did not vary across groups.

Neuroimaging has recently been used as a measure to assess the effectiveness of therapeutic interventions. Researchers have found differences in brain activation patterns following cognitive behavior therapy for a range of disorders, from depression (Siegle, Carter, & Thase, 2006) to spider phobia (Paquette et al., 2003). However, to date, there is no neurobiological evidence supporting brain function differences for gambling treatment.

Taken together, treatment approaches to suppressing addictive behaviors such as gambling, may need to focus beyond simple contingency manipulations such as restricted access, teaching people about odds of winning, or structural characteristics of the games themselves. Instead, we may need a greater understanding of how language and seemingly arbitrary contextual relationships may be impacting resistance to extinction at worst, and repeated losses over time at best (see also Weatherly & Dixon, 2007). Further, combining neurological measures with psychological assessments (common to clinical trials on addictive behaviors) is needed to understand the brain-behavior relationships that emerge following behavioral therapy. Therefore, the purpose of the present study was to examine the gambling of college-aged gamblers (18–20 years old) while they actually gambled in an fMRI scanner. Following initial scans, gamblers were randomly assigned to one of two groups: ACT or control. Gamblers assigned to the ACT group completed eight weeks of one-on-one therapy as developed by Dixon and Wilson (2014). All gamblers returned for post-test fMRI scans eight weeks following the initial scans, to determine the efficacy of ACT at a neurological level. If ACT could produce neurological traces within treated participants while controls remained constant across scans, these procedures would be the first to illustrate brain changes following ACT. Furthermore, such changes would provide evidence that contextual rearrangement of verbal stimuli have the ability to impact the person at a neurological level when exposed the very same stimuli as during baseline.

1. Methods

1.1. Participants, screening, and setting

Eighteen individuals participated in the current study, and were recruited on a Midwestern college campus. Potential participants were screened for gambling pathology using the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). Inclusion criterion included: a) a SOGS score of 3 or above and b) between 18 and 20 years of age at time of intake. The mean age of participants was 19.056 (SD=.848). All participants were male, 67% were African American (33% European American), and 56% reported an attempt to stop gambling at least once in the last 6months. Average participant SOGS scores were 6.5 (SD=3.02). The Human Subjects Committee of Southern Illinois University Carbondale approved the study.

Experimental sessions took place at an imaging center at the local hospital, while gambling treatment sessions took place in a small office on a college campus. For experimental sessions, participants were placed in a scanning room containing the fMRI scanner and other equipment, including a MRI-compatible LCD screen used for stimulus presentation and recording of subject responses. All MRI technicians and experimenters were in an adjoining control room throughout the scanning process. Gambling treatment sessions took place in a small office containing two chairs, a couch, three slot machines, a personal computer, video camera, and office furniture. All gambling treatment sessions were recorded for treatment integrity.

Each participant received a $200 gift card at the completion of all study procedures, including $25 for participation in each MRI scan ($50 total) and the amount won during the scan ($75 per scan; $150 total). Participants who were randomly assigned to the treatment group received an additional $25 ($225 total) for completion of all eight treatment sessions. All participants were informed prior to the start of the experiment that they would receive at least $200 at the end of their participation.

1.2. Apparatus

fMRI scans were acquired on a Philips Intera 1.5 T magnet: T2* single-shot EPI, TR =2.5 s, TE =50 ms, flip angle =90°, FOV =220 × 220 mm^2, 64 × 64 matrix, 3.44 × 3.44 × 5.5 mm voxels, 26 × 5.5 mm axial slices, 0 mm gap, and the first eight images were discarded. All data collected during the fMRI scans were analyzed with SPM 8 implemented in Matlab (Mathworks). All images were (1) slice time corrected for acquisition order, (2) realigned and motion corrected to the first image of the session, (3) normalized to a common template (Montreal Neurological Institute EPI template), (4) resliced to 2 × 2 × 2 mm voxels, and (5) spatially smoothed with a 10 mm Gaussian filter. A 128 s high pass filter was applied to each time series to eliminate low frequency noise. Single-subject statistical contrasts were created using the general linear model (GLM) with conditions of interest being Wins, Near-Misses, and Losses both pre-ACT and following ACT. These conditions (Wins, Near-Misses, and Losses at both Pre-ACT and Post-ACT times) were modeled using a canonical hemodynamic response function. Group comparisons across time were created using a random effects model, and contrasts were set at $p < 0.001$ uncorrected for multiple comparisons. Coordinates are presented in the Talairach and Tournoux (1988) system.

1.3. Dependent measures and reliability

Primary dependent measures included brain activation patterns and subjective ratings of outcomes during the fMRI task. Blood oxygenation level dependent (BOLD) signal was collected during the fMRI tasks for each participant. BOLD activation was contrasted between groups (i.e., treatment and control), time (i.e., pretest, 8 weeks following), and slot machine outcome (i.e., Wins, Losses, and Near-Misses). Participant subjective ratings of slot machine outcomes were also collected during the fMRI tasks. Participants rated how close each slot machine outcome was to a win using a five point Likert scale (1= not at all close, 5= extremely close).

Secondary measures included psychometric surveys that were completed either via computer or paper-pencil responding before each fMRI task. Four measures were included to assess the effects of the intervention: the Acceptance and Action Questionnaire II (AAQ-II; Bond et al., 2011); the Valued Living Questionnaire (VLQ; Wilson, Sandoz, Kitchens, & Roberts, 2011); and the Mindful Awareness Attitude Scale (MAAS; Brown and Ryan, 2003).

1.4. Acceptance and Action Questionnaire II

The AAQ-II (Hayes, Strosahl, Wilson, & Bissett, 2004; Bond et al., 2011) is a measure of experiential avoidance based off a functional contextual theory of language and cognition. This seven-item assessment includes statements such as "I'm afraid of my feelings" and "I worry about not being able to control my worries and feelings". Higher scores reflect psychological inflexibility and experiential avoidance, while lower scores reflect an individual's flexibility or acceptance and willingness.

1.5. Valued living questionnaire

The VLQ (Wilson et al., 2011) was originally developed as a clinical evaluation tool, specifically targeting values as a core ACT process. The two-part instrument measures the perceived importance and the consistency to which an individual behaved in accordance with ten specific value domains (e.g., marriage/intimate relations, parenting, employment/career, education/personal growth, recreation, spirituality, etc.). Each domain is scored on a 10 point Likert scale, where ratings are composited by multiplying responses per category by domain, and summing across domains. The sum of all domains are divided by 10, resulting in the valued living composite score. Higher composite scores are indicative of living in accordance with ones values. Preliminary evidence suggests the measurement has adequate internal consistency (α=.77) and test re-test reliability (interclass correlation coefficient =.75, p < 0.001), and has significant correlations with other psychological distress measures including depression and experiential avoidance (Wilson et al., 2011).

1.6. Mindful Attention Awareness Scale

The MAAS (Brewer et al., 2011) is a fifteen-item measure assessing the frequency of mindfulness states over time. This measure focuses on attention and awareness during the present moment by measuring the propensity of mindfulness during daily activities. Using a 6-point Likert scale, respondents indicate the frequency of each statement. Higher scores reflect mindful behaviors and engagement in life.

1.7. Procedure

A mixed 2 (group: ACT, Control) × 2 (condition: wins, losses) × 2 (time: pre, lost) design was used to assess brain activation during a gambling task. Conditions included outcomes observed by participants during the gambling task, and were categorized as losses (comprised of loss and near-miss outcomes) and wins. Participants first completed the informed consent, demographic questionnaires on overall medical, psychological, and neurological history, as well as any MRI

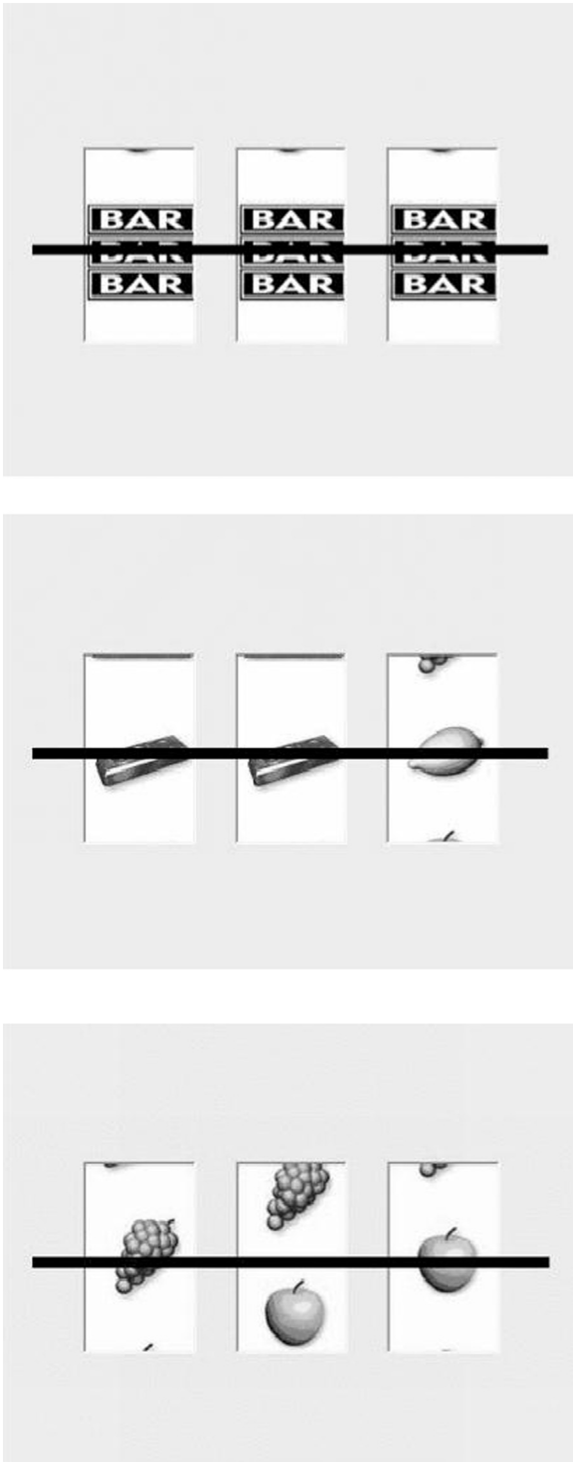

Fig. 1. Sample of stimuli presented to participants during the gambling activity. The top panel represents a winning outcome; the middle panel represents a near-miss outcome, while the bottom panel represents a losing outcome.

contraindications. After participants were cleared for inclusion by the MRI technician, participants were led into the MRI scanning room and asked to lie down on a 2.5 m table, and fitted with MRI compatible sound dampening headphones (used to communicate with the participant) and corrective eyewear if necessary. Next, a MRI compatible response pad was attached to each participant's right hand. Participants pressed the corresponding fingers at various points during the scanning activity to progress through the study (e.g., instruction screen, slot machine outcome self-report, etc.), and to rate each slot machine outcome.

Once in the scanner, participants viewed stimuli on an 18-cm (diagonal) MRI-compatible LCD screen through a mirror attached to the inside of the head coil at a distance of 15 cm. Stimuli presented to participants during the gambling activity are represented in Fig. 1. Participants read the following instructions prior to the start of the experiment:

> "You are going to play a computerized slot machine game. You will have $10 to begin with. Each spin costs $.05. A win will pay $.10 unless all symbols are 777 in which case it will pay $2.00. Your task is to rate how close to a win you feel each outcome is. Please make the decision after the slot machine wheels have stopped spinning.
> Press your thumb if you feel that the outcome is very close to a win. Press with your index finger if you feel that the outcome is close to a win. Press with your middle finger if you feel that the outcome is somewhat close to a win. Press with your ring finger if you feel that the outcome is somewhat close to a loss. Press with your pinky finger if you feel that the outcome is very close to a loss.
> During the scan please remain as still as possible. Do not move your feet and only move your fingers to respond. Try your best to minimize your head movements and eye blinks. Do you have any questions? "

The experimenter answered any questions before starting the experiment.

1.8. Scanning Procedures

Participants were scanned while viewing the wheels of a computerized slot machine programmed on E-Prime 1.0 software (Psychology Software Tools, Pittsburgh, PA). Each wheel spin consisted of a sequence of static images presented in rapid succession. The presentation rates of images were shown in a progression to give the illusion of spinning slot machine wheels, gradually slowing down and eventually stopping on an outcome for 2.5 s The first seven images were shown in rapid succession over 30 ms, the next two images shown for 45 ms, the next four for 50 ms, the next four images for 100 ms, and the last three images were shown for 200 ms. Total wheel spin time was 1.5 s, and stopped for 2.5 s on one of two equally divided outcomes: win (three identical symbols on the payout line) or a loss (less than two identical symbols on the payout line). On each trial, participants were required to rate how close each outcome was to a win immediately after the wheel stopped spinning.

Each participant was staked with $10 at the beginning of the scan. Each spin cost $.05, and winning outcomes were programed at either $2 or $.10, resulting in a total of $50 at the end of the scan.

A total of five functional runs were acquired for each participant, each run lasting 5 min and 20 s The images collected during the first 20 s were discarded, as the magnetic field was being stabilized during this time. For each run, participants viewed 60 wins, and 60 losses (including near-miss outcomes). Images collected throughout each run were subsequently categorized across outcome (wins and losses). Outcomes were presented in random order. Participants completed two fMRI sessions before and after 8 weeks of either gambling treatment or no treatment (see also Habib & Dixon, 2010, and Dixon, Wilson, & Habib, 2014 for similar scanning procedures).

1.9. Therapeutic intervention

There were two levels of the independent variable: treatment and no treatment. For participants who were randomly assigned to the treatment condition, the first ACT session was scheduled for the week following the initial experimental gambling session. Treatment sessions were 60 min each, over eight weeks, and were developed from Dixon, and Wilson A. N. (2014) gambling treatment model. During each treatment session, one or more of the six core ACT process was incorporated to address self-generated rule following related to the participant's gambling (see Table 1 for treatment overview). All participants received the same manualized treatment intervention. A brief overview of each component is provided below.

1.10. Acceptance

Acceptance included exercises that explicitly targeted participants' perspectives on control and willingness. Experiential exercises were included to allow for self-generated rule formulation. A gambling inventory was completed, where participants were asked to think about their gambling, what they experience as a result of their gambling, and how long gambling had been a problem. The metaphor "taking the bait" was created to highlight how urges and triggers to use functioned like a mouse trap, and suggested other ways to interact with the trap. Willingness exercises included "don't think about gambling," "fill in the blanks," and the "willingness to cash out."

1.11. Values

Values were defined as qualities that combine a string of moments together into a meaningful path, and emphasis was placed on the choice of the participant

Table 1
Treatment overview.

Week	ACT component	Experiential exercises
1	Mindfulness	–Where do you feel it? –Getting present
	Acceptance	–Gambling inventory: Tracking your gambling history
2	Values	–Mapping your values –Treasure box
	Acceptance	–Movie buff
	Mindfulness	–Noticing the moment
3	Acceptance	–If you're not willing…
	Defusion	–Taking the bait –10 relations to gambling –Deliteralizing gambling outcomes
	Mindfulness	–Experiencing gambling –Staying in the present moment
4	Acceptance	–Acceptance and gambling –Willingly cold
	Committed Action	–At the auction
	Defusion	–Getting stuck in the baggage claim –A thought is a thought, is a thought, is a thought…
5	Acceptance	–Almost willing –Acceptance, willingness, and the urge to gamble –Willingness 360
	Committed Action	–Willingness to cash out
	Mindfulness	–Where do you feel it?
6	Defusion	–Buying a win –Building space for gambling private events –Describing vs. evaluating –Physicalizing private events
7	Self as Context	–The you that's here, there, and everywhere you go –Who are you? –Battleship
	Values	–You and your values
8	Committed Action	–Making and breaking commitments –Potential barriers to staying committed
	Self as Context	–Staying present with the you, you want to be
	Values	–Staying committed to your values –Clarifying your values map

Note: exercises derived from Dixon and Wilson (2014); Hayes (2005)

on the "meaningfulness" of the path and the direction they travel. Participants were asked to think about what they valued in life across the 10 valued domains as identified by the VLQ, in combination with the behaviors they engaged in to get closer to those values. A "mapping your values" exercise was used to assist participants with identification and clarification of selected values and the barriers that get in the way of headed towards their values.

1.12. Present moment

Participants were provided with information regarding present moment focus, including differentiation between mindless and mindful behaviors. Participants were asked to notice their private events while playing on a real slot machine and while scrolling through various images, including arbitrary (random shapes and words), non-gambling specific (clocks, flowers, birds), and gambling specific images. During all present moment exercises, participants were asked to notice their thoughts/feelings, bodily sensations experienced, and how their private events changed over time. The exercise "where do you feel it? " was created to assist participants with tacting the location of their private events as they occurred during experiential exercises.

1.13. Defusion

Defusion exercises targeted cognitive fusion and literalization of language. A deliteralization exercises was created to focus on functions of the near miss, where participants were shown slides with images of near misses with the words "almost a win" and "is like a loss" repeated for just under 1 min Physicalizing exercises were also incorporated, where participants were asked to physicalize private events related to gambling (e.g., giving thoughts, feelings, and cravings about gambling shapes, colors, and unrelated names; see also Hayes, Strosahl, & Wilson, 1999). Similarly, language exercises were incorporated to highlight transformation of stimulus functions in gambling contexts, and were specialized to fit with each participant's unique gambling history.

1.14. Committed action

Experiential exercises were created to focus on behavioral activation and commitment to behavioral change. The metaphor "at the auction" was created to discuss how to stay committed to ones values in the presence of near miss outcomes. This metaphor highlighted the thoughts and feelings the participant experiences in the space of "almost," particularly as the auctioneer says "going once, going twice…" and when someone exceeds the participants' bid, leaving them almost winning the gift. Another committed action metaphor used was the "cashing out" metaphor. This metaphor was created to pair cashing out on a slot machine with getting closer to ones values.

1.15. Self as context

Participants were exposed to exercises that highlighted the distinction between the various forms of self. Exercises were presented in a way for participants to identify and contact the different perspectives on their experience, including the labels used to describe or evaluate their experience. One exercise in particular was the "Battleship" metaphor, an alteration of the common "chessboard" metaphor (Hayes, 2005). Here, participants were asked to imagine things they struggle with as the light boats with their values and the things they want their life to be about as the dark boats, battling it out. Participants were instructed to notice their role in the game, their position on who they wanted to win, and to consider taking the perspective of the board.

2. Results

2.1. Homogeneity of participants

The 18 participants included in the study were randomly assigned to one of two groups: treatment (age M=19.2, SD=.918) or control (age M=18.75, SD=.834). Participant characteristics did not differ between groups in terms of age (t(16)=.776, p =.925), race (χ^2=.45, p =.502), or SOGS scores (t(16)=−1.072, p =.228; treatment M=5.8, SD=2.39; control M=7.37, SD=3.815).

2.2. Subjective rating of slot machine outcomes

Participant subjective responses to Wins and Losses were averaged across the 30 min duration of slot machine play. Participant averages are represented in Fig. 2. A 2 (group: ACT, Control) × 2 (condition: wins, losses) × 2 (time: pre, lost) mixed-effects analysis of variance was carried out on the "closeness to a win" slot machine ratings. The analysis revealed a significant 3-way interaction between group,

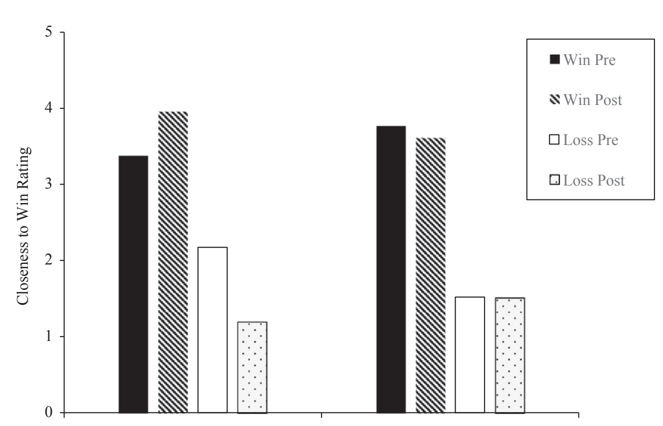

Fig. 2. Average closeness to win ratings across wins and losses.

Table 2
Activations in present study in close proximity to activations observed by Habib and Dixon (2010).

Present Study				Habib et al. (2010)			
X	Y	Z	Label	X	Y	Z	Label
Pre-Treatment Wins – Losses				Pathological Gamblers Wins – Losses			
−12	−4	−7	Ventral Striatum	−10	−18	−18	Midbrain
6	−91	16	Cuneus	8	−84	34	Cuneus
−26	5	−10	Amygdala	−20	3	−20	Uncus/Amygdala
20	−3	−12	Amygdala	26	−3	−23	Uncus/Amygdala
Post-treatment wins – losses				Non-pathological gamblers losses – wins			
51	−29	49	Inferior Parietal Lobule	40	−37	39	Inferior Parietal Lobule
−2	25	43	Medial Frontal Gyrus	−2	22	50	Superior Frontal Gyrus
−14	−76	42	Precuneus	8	−62	47	Precuneus
−34	4	44	Middle Frontal Gyrus	−44	6	49	Middle Frontal Gyrus

Note. Negative X values indicate left hemisphere; positive X values indicate right hemisphere.

condition, and time, $F(1, 16)=18.78$, $p<0.001$, partial $\eta=0.54$). The interaction reflects the fact that mean slot machine ratings for winning and losing outcomes did not differ in the control group (losses: pre =1.52, post =1.51; wins: pre =3.76, post =3.61) whereas the ratings did differ in the treatment group (losses: pre =2.173, post =1.12; wins: pre =3.38, post =3.95). Paired-samples *t*-tests confirmed that the pre – post difference was only significant for the Treatment group for both spin outcomes (Wins: $t(9)=3.56$, $p<0.01$; Losses: $t(9)=5.60$, $p<0.001$).

2.3. fMRI results

fMRI activations were examined between Wins and Losses in both the Control and Treatment groups before and after the eight-week intervention (or eight-week no intervention). To analyze the data from the initial scanning session, before gamblers were randomly assigned to a group, all 18 subjects (10 Treatment +8 Control) were combined and brain regions demonstrating greater activation following Wins than Losses were identified using a statistical threshold of $p<0.001$ uncorrected for multiple comparisons, and an extent threshold of 5 contiguous voxels.

Table 2 represents brain activations of all participants before treatment, and treatment-only participants after treatment, as compared to activations observed by Habib et al. (2010). Regions demonstrating greater activity following winning than losing spins across all pathological gamblers included the left middle temporal gyrus (xyz=−53 3 −20, Z=3.69, k =92), left ventral striatum (xyz=−24 −8 −3, Z=3.35, k=48; xyz=−12 −4 −8, Z=3.24, k=35), right fusiform gyrus (xyz=42 −28 −10, Z=3.2, k=12), cuneus (xyz=6 −91 16, Z=3.06, k=22), and ventral striatum near the substantia nigra (xyz=8 −2 −8, Z =3.02, k=21). Activation in the right amygdala was observed slightly below the set threshold and so should be interpreted cautiously (xyz=20 −3 −12, Z=2.94, k=12).

In the follow up scanning session, the Win – Loss contrast was examined once again, but this time separately for the Treatment and Control groups. In the Control group, no regions demonstrated greater activity following Winning than Losing spins during the follow up scanning session than in the initial scanning session. That is, there were no regions with increased activation following winning outcomes after eight weeks than during the initial scan for control participants.

The pattern of activity was different for the participants that received eight weeks of ACT. In this group, greater activations following Winning than Losing spins after treatment compared to the initial scanning session were noted in frontal and parietal brain regions: right inferior parietal lobule (xyz=51 −29 49, Z=4.09, k=198), left precentral gyrus (xyz=−22 −13 45, Z=3.65, k=111), left superior temporal gyrus (xyz =−42 −48 8, Z =3.62, k=156), right middle temporal gyrus (xyz=40 −12 −16, Z =3.47, k=49), left posterior cingulate gyrus (xyz=−28 −30 27, Z=3.28, k 45), bilateral medial frontal gyrus (xyz =18 −11 45, Z=3.23, k=154; xyz =−2 25 43, Z =3.13, k =39), bilateral middle frontal gyrus (xyz=48 40 28, Z=3.13, k=28; xyz=−34 30 22, Z =3.03, k =19; xyz ==−34 4 44, Z=3.01, k=20), and the left precuneus (xyz=−14 −76 42, Z=3.09, k=45) (see also Fig. 3).

2.4. ACT treatment outcomes

Participant responses on the AAQ-II, VLQ, and MAAS were subjected to an independent paired samples *t*-test. All *p* values were considered significant at 0.05. Results indicated a significant difference between AAQ-II scores following treatment ($M=-9.7$, $SD=7.42$) when compared to control ($M=4.87$, $SD=13.45$), $t(16)=-2.927$, $p=.010$. A significant effect was also identified between MAAS scores following treatment ($M=-4.3$, $SD=6.34$) when compared to control ($M=-38.50$, $SD=9.7$), $t(16)=8.97$, $p<0.01$. However, a non-significant effect was identified between VLQ scores following treatment ($M=5.78$, $SD=21.65$) when compared to control ($M=-3.27$, $SD=9.5$), $t(16)=1.096$, $p=.289$ (see also Table 3)).

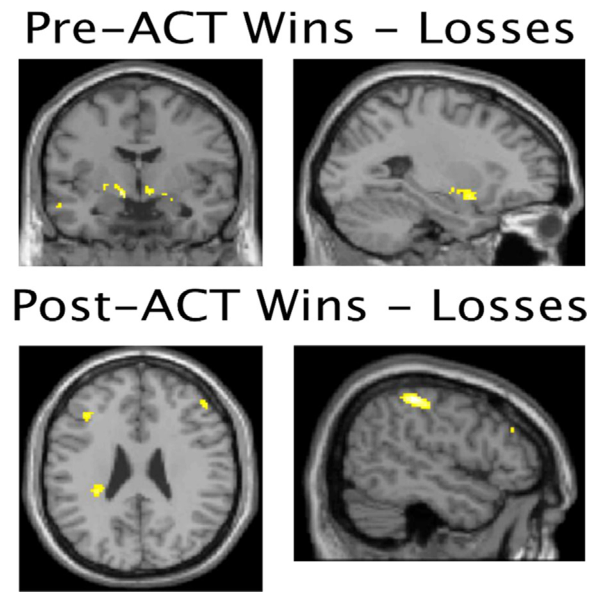

Fig. 3. Top Panel. Coronal (left) slice shows activation in bilateral ventral striatum. Sagittal (right) slice shows activation in left amygdala. Activation is greater for both Treatment and Control groups following a Winning spin outcome than a Losing spin outcome. Bottom panel. Horizontal (left) slice shows activation in bilateral middle frontal gyrus. Sagittal (right) slice shows activation in right inferior parietal lobule. Activation is greater for subjects in the Treatment group (8 weeks of ACT) following a Winning spin outcome than a Losing spin outcome.

3. Discussion

The current study sought to examine the possible neurological effects following eight weeks of ACT for college-age gamblers. The first fMRI scan revealed similar brain activation patterns across all participants, consistent with previous research (e.g., Dixon et al., 2014; Habib & Dixon, 2010; Potenza et al., 2003), as increased activation was identified in the dopaminergic system (e.g., ventral striatum, cuneus, and amygdala). However, participants who completed eight weeks of ACT, showed greater brain activation patterns for winning spins when compared to the initial scanning session; while participants in the control group showed no differentiation in brain activity following winning spins. The neurological change observed in the treatment group resembled similar brain activation patterns in regions as non-pathological gamblers as discussed in previous research (e.g., Habib et al., 2010). Consistent with previous research, all gamblers at the initial fMRI scan showed decreased activation in the dopaminergic activation centers, including the amygdala, cuneus, and ventral striatum (Dixon et al., 2014; Potenza et al., 2003). However, the difference between gamblers at posttest revealed interesting differences, particularly with increased activation in the middle frontal gyrus and inferior parietal lobule in gamblers receiving treatment. These findings mirror findings of non-pathological gamblers activation patterns reported by Habib and Dixon (2010).

Conceptually, these differences may suggest that when treatment-completed gamblers observed the winning stimuli, they psychologically “saw” the stimuli differently than before. If we consider the impact of a functional contextual intervention such as ACT, it seems plausible that the “win” of the slot machine now acquired additional functions such as “loss of time with family”,

Table 3
Psychometric data across group.

Group	Psychometric Assessment								
	AAQ-II			MAAS			VLQ		
	Pre	Post	F	Pre	Post	F	Pre	Post	F
	(*M/SD*)	(*M/SD*)	*df* (2, 16)	(*M/SD*)	(*M/SD*)	*df* (2, 16)	(*M/SD*)	(*M/SD*)	*df* (2, 16)
ACT	51.4 (12.89)	41.7 (14.67)	1.47*	64.8 (15.39)	60.5 (15.02)	4.307**	53.58 (19.54)	59.36 (26.5)	1.840
Control	52.13 (8.36)	57 (14.62)		57 (12.00)	18.5 (7.89)		57.32 (11.70)	54.05 (17.00)	

* $p \leq .001$.
** $p \leq .01$.

"disappointment on eliminating debt", or "taking time away from studying." While such additional relational networks are speculative at this point, the increased neurological activity in the prefrontal cortex does suggest this as a possibility. Future research may simply ask participants to verbally describe the top 5 things that come to their mind when they see the slot machine displays, and see if such a list is altered post-therapy.

Concomitantly, significant differences were found on participant responses to the AAQ-II and MAAS over time. Following treatment, gamblers were more likely to report higher engagement in psychological flexibility and mindfulness-related behaviors then gamblers who did not complete treatment. Interestingly, gamblers in both groups reported lower MAAS scores overall, with gamblers assigned to the control group reporting the largest decreases in MAAS scores over time. Further, subjective ratings of slot machine outcomes were significantly different between groups over time ($p < 0.01$). All participants responded similarly with subjective ratings of wins and losses during the first slot machine task. Over time, ratings for winning and losing outcomes differed significantly in the treatment group, but did not differ in the control group. Such differences in subjective ratings of slot machine outcomes following ACT are consistent with previous research (e.g., Nastally & Dixon, 2012). At post-treatment, it also appears that the self-report loss ratings reduced and win ratings increased when compared to a constant rating shown in the control group. Although this was not directly targeted in treatment, it is possible that the ACT intervention aided in clarifying the objective nature of each outcome, thus producing these disparity ratings when compared to pre-treatment. If we were to speculate about the ACT mechanism responsible, it would be hypothesized that the present moment awareness component of treatment aided in this effect. Future research may also attempt to separate the various components of ACT and see how individually they may or may not contribute to similar effects.

Taken together, these results suggest that both behavioral and neurological differences emerge following eight weeks of ACT when compared to a no-treatment control group. From an ACT perspective, focusing on the present moment helps to foster committed valued-based action in the presence of appetitive and aversive stimuli. In other words, derived relations that dominate sources of behavioral regulation (i.e., maladaptive gambling patterns) were indirectly targeted through metaphor and experiential exercises. The current study highlights how ACT can assist gamblers with engaging in psychological flexibility and present moment awareness, particularly during a gambling task. Behavioral change in psychological flexibility and awareness during a gambling task were identified through both neurological and behavioral measures.

Similarly, the current study provides a framework for utilizing physiological and behavioral measures to assess the effectiveness of a behavioral intervention. These data provide evidence on how a behavioral analysis can use a neurological measure to determine change following manipulation of an independent variable, without needing a neurological analysis to be the cause of the behavioral change (e.g., Habib and Dixon, 2010). Previous research has identified brain activation differences following behavioral interventions across a range of populations (Cozolino, 2010) including phobia (Paquette et al., 2003) and substance use disorders (DeVito et al., 2012). Recent technological advancements in magnetic imaging has made accessing the world "within the skin" (Skinner, 1945) easier and more reliable. The current study highlights the utility of combining neurological and behavioral measures to understand differences in private events over time.

The inclusion of college-aged gamblers is also noteworthy. While gambling prevention strategies abound for adolescents and under-age young adults (Ladouceur, Goulet, & Vitaro, 2013), to date, minimal treatment interventions have targeted this at-risk population. This is concerning given the risk factors of college-aged to develop disordered gambling. The current study provides preliminary evidence in support of using ACT for this population.

While the current study is the first to identify neurological changes in gamblers following ACT, the study is not without limitations. The treatment protocol could be considered a multicomponent intervention, as it contained many different independent variables which may have been in part or not at all responsible for behavior / neurological change. At the level of ACT as an intervention, it is uncertain if a specific factor within in the hexaflex altered the dependent variables. For example, present moment awareness alone may have been sufficient to bring about changes (see Brewer et al., 2011 for theoretical overview of mindfulness-based interventions for substance use disorders). In contrast, perhaps self as context added nothing to the treatment. Future research might consider conducting a component analysis to determine if the entire ACT treatment presented here was critical to implement.

The treatment dose and manualized nature of treatment delivery may also function as limitations. The ACT intervention used a standardized eight-week intervention dose to ensure treatment integrity and provide a uniformed level of the independent variable across subjects. It is possible that some participants may have needed a few more weeks of sessions to increase its effectiveness. Conversely some participants may not have needed the entire eight sessions, thus the additional sessions were postponing our discovering of the minimal effective treatment dose. Similarly, our treatment was delivered in a topographically identical fashion to all participants regardless of the underlying mechanisms as to why they gambled in the first place (e.g., accessing escape vs. accessing social attention or tangible items). Future research should explore how an individual gambler's triggers or antecedents that occasion their gambling might be isolated during more client-driven individualized treatment sessions.

The subjective ratings of closeness to a win effectively produced reports which delineated different slot outcomes from each other. However, it is possible that these ratings were partially influenced by the question itself and not solely a product of the psychological experience of the slot display. While previous research has used different types of questions to assess subject self-reports on slot outcomes (e.g., Chase & Clark, 2010; Habib and Dixon, 2010), to date, no study has compared responses for identical slot outcomes across multiple questions. Therefore, future research may wish to consider using multiple topographies of questioning (e.g., “How close were you to a win? ” or “How happy are you with the outcome?”).

Finally, this study used a very restricted age range of non-treatment seeing problem gamblers. It remains unknown how these two critical variables impacted our obtained data as well as limit the external validity of our findings. This population does hold some positive aspects however, as we documented underage college gamblers could show positive treatment outcome, and thus our treatment model may be useful on other college campuses.

Behavioral interventions for addiction in general are hard to validate, particularly for addictions where there is no physical consumption involved in the process. The current study attempted to validate the use of ACT for disordered gambling by combining standardized psychometric assessments and self-reports with physiological measures (e.g., fMRI). By doing so, the current study raises the bar of validating measures used to determine the effectiveness of ACT on events that occur within the skin. Future research should continue to determine the effects of therapeutic interventions across levels of analyses, to include events that occur within the skin. In doing so, objective measurement systems can be used to understand changes to private events following therapeutic interventions. Even though skeptics abound within the behavioral sciences to using methods and outcomes typically limited to the cognitive sciences (such as fMRI), a great deal of utility can be gained by adoption of such an approach. Our study illustrates that the internal neurological processes that occur as a result of gambling can be maintained at the level of a dependent variable, and not a causal agent. It is perhaps here where the misunderstanding of neurological metrics lies. Although cognitive neuroscientists appease to such brain states as a cause of behavior, we as behavioral scientists can maintain our stance of environmental determinants of behavior by simply viewing neurological activities as a behavior, like any other sort of easier observed behavior. When such neurological activities have the ability to tell a story of therapeutic effectiveness, which had previously been left to self-reports, it appears that it is long overdue to embrace the potential of neuroimaging to validate treatment efficacy.

References

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*, 469–480.

Barnes-Holmes, Y., Barnes-Holmes, D., McHugh, L., & Hayes, S. C. (2004). Relational frame theory: Some implications for understanding and treating human psychopathology. *International Journal of Psychology and Psychological Therapy*, *4*(2), 355–375.

Bond, F. W., Hayes, S. C., Baer, R. A., Carpenter, K. M., Guenole, N., Orcutt, H. K., & Zettle, R. D. (2011). Preliminary psychometric properties of the Acceptance and Action Questionnaire–II: a revised measure of psychological inflexibility and experiential avoidance. *Behavior Therapy*, *42*(4), 676–688.

Brewer, J. A., Bowen, S., Smith, J. T., Marlatt, G. A., & Potenza, M. N. (2011). Mindfulness-based treatments for co-occurring depression and substance use disorders: What can we learn from the brain? *Addiction*, *105*(10), 1698–1706. http://dx.doi.org/10.1111/j.1360–0443.2009.02890.x.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*(4), 822.

Catania, A. C., Horne, P., & Lowe, C. F. (1989). Transfer of function across members of an equivalence class. *The Analysis of Verbal Behavior*, *7*, 99–110.

Chase, H. W., & Clark, L. (2010). Gambling severity predicts midbrain response to near-miss outcomes. *The Journal of Neuroscience*, *30*(18), 6180–6187. http://dx.doi.org/10.1523/JNEUROSCI.5758–09.2010.

Cozolino, L. (2010). *The Neuroscience of psychotherapy*. New York: W. W. Nortion,.

Derevensky, J. L., & Gupta, R. (2000). Prevalence estimates of adolescent gambling: a comparison of the SOGS-RA, DSM-IV-J, and the GA 20 Questions. *Journal of Gambling Studies*, *16*, 227–252.

DeVito, E. E., Worhunsky, P. D., Carroll, K. N., Rounsaville, B. J., Kober, H., & Potenza, M. N. (2012). A preliminary study of the neural effects of behavioral therapy for substance use disorders. *Drug and Alcohol Dependence*, *122*, 228–235.

Dixon, M. R., Bihler, H. L., & Nastally, B. L. (2011). Slot machine preferences of pathological and recreational gamblers are verbally constructed. *Psychological Record*, *61*(1), 6.

Dixon, M. R., Nastally, B. L., Jackson, J. E., & Habib, R. (2009). Altering the near-miss effect in slot machine gamblers. *Journal of Applied Behavior Analysis*, *42*(4), 913.

Dixon, M. R., Wilson, A., & Habib, R. (2014). Neurological correlates of slot machine win size in pathological gamblers. *Behavioural Processes*, *104*, 108–113.

Dixon, M. R., & Wilson, A. N. (2014). *Acceptance and commitment therapy for pathological gamblers*. Chicago, IL: Shawnee Scientific Press,.

Dixon, M. R., Wilson, A. N., & Whiting, S. W. (2012). A preliminary investigation of relational network influence on horse-track betting. *Analysis of Gambling Behavior*, *6*(1), 23–36.

Dougher, M., Perkins, D. R., Greenway, D., Koons, A., & Chiasson, C. (2002). Contextual control of equivalence-based transformation of functions. *Journal of the Experimental Analysis of Behavior*, *78*(1), 63–93.

Dougher, M. J., Hamilton, D. A., Fink, B. C., & Harrington, J. (2007). Transformation of the discriminative and eliciting functions of generalized relational stimuli. *Journal of the Experimental Analysis of Behavior*, *88*(2), 179.

Dougher, M. J., & Markham, M. R. (1994). Stimulus equivalence, functional equivalence, and the transfer of function In: S. C. Hayes, M. Sato, & K. Ono (Eds.), *Behavior analysis of language and cognition* (pp. 71–90). Reno, NV: Context Press.

Dougher, M. J., & Markham, M. R. (1996). Stimulus classes and the untrained acquisition of stimulus functions In: T. R. Zentall, & P. M. Smeets (Eds.), *Stimulus class formation in humans and animals* (pp. 137–152). Amsterdam: Elsevier.

Dymond, S., & Rehfeldt, R. A. (2000). Understanding complex behavior: The transformation of stimulus functions. *The Behavior Analyst*, *23*, 239–254.

E. K., Sandoz, K. G., Wilson, & T., Dufrene (2010). *Acceptance and commitment therapy for eating disorders.* Oakland, CA: New Harbinger Publications.

Goldstein, R. Z., & Volkow, N. D. (2002). Drug addiction and its underlying neurobiological basis: Neuroimaging evidence for the involvement of the frontal cortex. *American Journal of Psychiatry*, *159*(10), 1642–1652.

Gooding, P., & Tarrier, N. (2009). A systematic review and meta-analysis of cognitive-behavioural interventions to reduce problem gambling: Hedging our bets? *Behaviour Research and Therapy*, *47*(7), 552–607.

Habib, R., & Dixon, M. R. (2010). Neurobehavioral evidence for the “near-miss” effect in pathological gamblers. *Journal of the Experimental Analysis of Behavior*, *93*(3), 313–328. http://dx.doi.org/10.1901/jeab.2010.93–313.

Hayes, S. C. (2005). *Get out of your mind and into your life*. Oakland: New Harbinger,.

Hayes, S. C., Barnes-Holmes, D., & Roche, B. (2001). *Relational frame theory: A post-Skinnerian account of human language and cognition*. New York: Plenum,.

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change*. New York: Guilford Press,.

Hayes, S. C., Strosahl, K., Wilson, K. G., & Bissett, R. T. (2004). Measuring experiential avoidance: A preliminary test of a working model. *The psychological record*, *54*(4), 553.

Hodgins, D. C., Currie, S. R., & el-Guebaly, N. (2001). Motivational enhancement and self-help treatments for problem gambling. *Journal of Consulting and Clinical Psychology*, *69*(1), 50.

Hoon, A., Dymond, S., Jackson, J. W., & Dixon, M. R. (2008). Contextual control of slot-machine gambling: Replication and extension. *Journal of Applied Behavior Analysis*, *41*(3), 467–470. http://dx.doi.org/10.1901/jaba.2008.41–467.

King, S. M., Abrams, K., & Wilkinson, T. (2010). Personality, gender, and family hisorty in the prediction of college gambling. *Journal of Gambling Studies*, *26*, 347–359. http://dx.doi.org/10.1007/s10899–009–9163–7.

LaBrie, R. A., Shaffer, H. J., LaPlante, D. A., & Wechsler, H. (2003). Correlates of college student gambling in the United States. *Journal of American College Health*, *52*, 53–62.

Ladouceur, R., Goulet, A., & Vitaro, F. (2013). Prevention programmes for youth gambling: A review of the empirical evidence. *International Gambling Studies*, *13*(2), 141–159. http://dx.doi.org/10.1080/14459795.2012.740496.

Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (The SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry*, *144*, 1184–1188.

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston: Authors Cooperative.

Nastally, B. L., & Dixon, M. R. (2012). The effect of a brief acceptance and commitment therapy intervention on the near-miss effect in problem gamblers. *The Psychological Record*, *62*(4), 677.

N. M., Petry (2005). *Pathological gambling: etiology, comorbitidy, and treatment.* Washington DC: American Psychological Association.

Oei, T. P. S., & Raylu, N. (2004). Familial influence on offspring gambling: A cognitive mechanism for transmission of gambling behavior in families. *Psychological Medicine*, *34*(7), 1279–1288.

Paquette, V., Lévesque, J., Mensour, B., Leroux, J. M., Beaudoin, G., Bourgouin, P., & Beauregard, M. (2003). Change the mind and you change the brain: Effects of cognitive-behavioral therapy on the neural correlates of spider phobia. *NeruoImage*, *18*, 401–409. http://dx.doi.org/10.1016/S1053–8119(02)00030–7.

Petry, N. M., Weinstock, J., Morasco, B. J., & Ledgerwood, D. M. (2009). Brief motivational interventions for college student problem gamblers. *Addiction*, *104*(9), 1569–1578.

Potenza, M. N., Steinberg, M. A., Skudlarski, P., Fulbright, R. K., Lacadie, C. M., Wilber, M. K., et al. (2003). Gambling urges in pathological gambling: a functional magnetic resonance imaging study. *Archives of General Psychiatry*, *60*(8), 828–836.

Potenza, M. R. (2008). The neurobiology of pathological gambling and drug addiction: An overview and new findings. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*, 3181–3189.

Rehfeldt, R. A., & Hayes, L. J. (1998). Untrained temporal differentiation and equivalence class formation. *The Psychological Record*, *48*(3), 481.

De Ruiter, M. B., Veltman, D. J., Goudriaan, A. E., Oosterlaan, J., Sjoerds, Z., & van den Brink, W. (2009). Response perseveration and ventral prefrontal sensitivity to reward and punishment in male problem gamblers and smokers. *Neuropsychopharmacology*, *34*(4), 1027–1038.

Ruiz, F. J. (2012). Acceptance and commitment therapy versus traditional cognitive behavioral therapy: A systematic review and meta-analysis of current empirical evidence. *International Journal of Psychology and Psychological Therapy*, *12*, 333–357.

Shaffer, H. J. (2000). Introduction: Youth gambling. *Journal of Gambling Studies*, *16*, 113–114.

Shaffer, H. J., & Hall, M. N. (2001). Updating and refining prevalence estimates of disordered gambling behavior in the United States and Canada. *Canadian Journal of Public Health*, *92*, 168–172.

Shah, K. R., Potenza, M. S., & Eisen, S. A. (2004). Biological basis for pathological gambling In: J. E. Grant, & M. N. Potenza (Eds.), *Pathological gambling: A clinical guide to treatment* (pp. 127–142). Washington, D.C: American Psychiatric Publishing, Inc.

Sidman, M. (1969). Generalization gradients and stimulus control in delayed matching-to-sample. *Journal of the Experimental Analysis of Behavior*, *12*(5), 745.

Siegle, G., Carter, C., & Thase, M. (2006). Use of fMRI to predict recovery from unipolar depression with cognitive behavior therapy. *American Journal of Psychiatry*, *163*(4), 735–738. http://dx.doi.org/10.1176/appi.ajp.163.4.735.

Skinner, B. F. (1945). The operational analysis of psychological terms. *Psychological Review*, *52*(5), 270–277.

Skinner, B. F. (1959). *Cumulative record*. New York: Appleton-Century-Crofts,.

Slutske, W. S., Eisen, S. A., Xian, H., True, W., Lyons, M. J., Goldberg, J., et al. (2001). A twin study of the association between pathological gambling and antisocial personality disorder. *Journal of Abnormal Psychology*, *110*, 297–308.

Stinchfield, R., Hanson, W. E., & Olson, D. H. (2006). Problem and pathological gambling among college students. *New Directions for Student Services*, *113*, 63–72.

Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic atlas of the human brain*. New York: Thieme Medical Publishers,.

Twohig, M. P., Shoenberger, D., & Hayes, S. C. (2007). A preliminary investigation of acceptance and commitment therapy as a treatment for marijuana dependence in adults. *Journal of Applied Behavior Analysis*, *40*, 619–632 doi:101901/jaba.2007.619–632.

Wareham, J. D., & Potenza, M. N. (2010). Pathological gambling and substance use disorders. *The American Journal of Drug and Alcohol Abuse*, *36*, 242–247. http://dx.doi.org/10.3109/00952991003721118.

Weatherly, J. N., & Dixon, M. R. (2007). Toward an integrative behavioral model of gambling. *Analysis of Gambling Behavior*, *1*(1), 4–18.

Williams, R. J., Volberg, R. A., & Stevens, R. M. (2012). The population prevalence of problem gambling: Methodological influences, standardized rates, jurisdictional differences, and worldwide trends. *Ontario Problem Gambling Research Centre*.

Wilson, A. N., & Dixon, M. R. (2015). Derived rule tacting and subsequent following by slot machine players. *The Psychological Record*, *65*(1), 13–21. http://dx.doi.org/10.1007/s40732–014–0070–7.

Wilson, A. N., & Grant, T. (2015). Implications of Derived Rule Following of Roulette Gambling for Clinical Practice. *Behavior Analysis in Practice*, *8*(1), 52–56.

Wilson, K. G., Sandoz, E. K., Kitchens, J., & Roberts, M. (2011). The Valued Living Questionnaire: Defining and measuring valued action within a behavioral framework. *The Psychological Record*, *60*(2), 249–272.

Winters, K. C., Bengston, P., Dorr, D., & Stinchfield, R. (1998). Prevalence and Risk Factors of Problem Gambling Among College Students. *Psychology of Addictive Behaviors*, *12*, 127–135.

Zlomke, K. R., & Dixon, M. R. (2006). Modification of slot-machine preferences through the use of a conditional discrimination paradigm. *Journal of Applied Behavior Analysis*, *39*(3), 351–361.