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# An Evaluation of the Impact of Medication on Behavioral Intervention Effectiveness for Adults with Traumatic Brain Injury

Sulay Martinez  
smartinez1@rollins.edu

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**An Evaluation of the Impact of Medication on Behavioral Intervention Effectiveness for  
Adults with Traumatic Brain Injury**

A Capstone  
By  
**Sulay Martinez**

Submitted to the Faculty of the Department of Health Professions  
at Rollins College in Partial Fulfillment  
of the Requirements for the Degree of

**MASTER OF ARTS IN APPLIED BEHAVIOR ANALYSIS AND CLINICAL SCIENCE**

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### **Abstract**

A systematic search of the literature was conducted to identify articles implementing both pharmacological and behavioral interventions with subjects with traumatic brain injury (TBI). Limitations of pharmacological interventions were evaluated and compared to the implications for behavioral interventions for adults with TBI. Results of this study indicate further research is necessary to adequately evaluate the effects of medication on behavioral intervention effectiveness for adults with TBI.

## Introduction

The field of behavior analysis has spent decades evaluating the science behind human behavior. Through this systematic and scientific evaluation emerged applied behavior analysis (ABA). The aim of ABA is to use empirically supported interventions to increase socially appropriate behavior and decrease problem behavior on an individual level (Cooper, Heron, & Heward, 2007). By applying the principles of operant and respondent conditioning, ABA can improve behavior excess and deficits for an individual to function optimally in his or her culture. According to Baer, Wolf, and Risley (1968), the following are the seven dimensions of ABA which must be used when evaluating research:

- *Applied*: socially significant behavior is selected
- *Behavioral*: focuses on directly observable and measurable events
- *Analytical*: demonstrates functional relationship; decisions are data based
- *Technological*: defines procedures clearly and objectively
- *Conceptually systematic*: interventions consistent with principles demonstrated in the literature
- *Effective*: demonstrates socially significant behavior change
- *Generality*: extends behavior change across time, setting, or other behavior

The seven dimensions of ABA allow for an empirical evaluation of behavior. To evaluate behavior and facilitate the goals of ABA, there are a wide variety of assessments and interventions used. Typically, preference assessments and reinforcer assessments are used before conducting interventions to determine client preferences and effective reinforcers (Cooper et al., 2007). Other assessment tools, such as the functional analysis (FA), allow behavior analysts to determine the maintaining variables of an individual's problem behavior, also referred to as the

function of problem behavior. Once preferences, reinforcers, and function of problem behavior have been identified, intervention can begin. Some common interventions include functional communication training (FCT), differential reinforcement, extinction (EXT), noncontingent reinforcement (NCR), shaping, and prompting (Cooper et al., 2007).

Although behavior analysis has often been recognized for the treatment of individuals with autism spectrum disorder (ASD) and other intellectual disabilities, through dissemination the application of ABA has been successful in a multitude of clinical applications which include feeding disorders, drug abstinence, gerontology, health and fitness, physical disabilities, brain disabilities and even pharmacology (Roane, Ringdahl, & Falcomata, 2015; Zimmerman & Poling, 2016). Due to the individualized nature of ABA, ABA should be considered and further evaluated as an effective rehabilitation intervention for individuals with traumatic brain injury (TBI).

### **Traumatic Brain Injury**

According to the Brain Injury Association of America (BIAA; n.d.), a traumatic brain injury is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force. More specifically, the Center for Disease Control and Prevention (CDC; 2015) cites an observation of any one of the following as an alteration in brain function:

- Any period of loss of or decreased consciousness;
- Any loss of memory for events immediately before (retrograde amnesia) or after the injury (post-traumatic amnesia);
- Neurologic deficits such as muscle weakness, loss of balance and coordination, disruption of vision, change in speech and language, or sensory loss; or



- Any alteration in mental state at the time of the injury such as confusion, disorientation, slowed thinking, or difficulty with concentration.

Typically, a fall, motor vehicle accident, or sport-related injury is the cause of a TBI. In 2010 alone, 2.5 million individuals in the United States were affected with a TBI, making it a leading cause of death and disability (CDC, 2010). Individuals suffering from severe TBI exhibit problems in cognitive function, motor function, sensation, and emotion (CDCP, 2010).

Additionally, those problems can result in difficulties with daily living such as household tasks, employment, and relationships with family and friends.

### **Brain Injury Rehabilitation**

There are several TBI rehabilitation options based on the severity of the injury. Acute rehabilitation occurs as soon as possible and includes assistance with daily living activities such as dressing, eating, using the restroom, and talking. Post-acute rehabilitation is more intensive and is aimed at increasing independence. Sub-acute rehabilitation is less intensive and designed for individuals who are not making rapid functional gains. Day treatment occurs in a group setting typically following discharge from an in-patient post-acute rehabilitation center. Finally, outpatient therapy facilitates maintenance of rehabilitation gains (CDC, 2010).

### **Medication Associated with Brain Injury**

Currently there are no medications available to reverse the physiological or behavioral effects of TBI (BIAA, 2018). Although there are currently no medications prescribed to treat brain injuries, there are often comorbid symptoms which require pharmacological intervention. Common medications include anticonvulsants, anti-psychotics, cognition, and pain management medications. These medications are often associated with severe side effects (BIAA, 2018).

The severe side effects of pharmacological interventions ultimately interfere with the efficacy and effectiveness of treatment. Common side effects include drowsiness, nausea and vomiting, headaches, and confusion/memory loss. Table 1 displays common medications associated with the treatment and management of TBI related symptoms and side effects.

Ostrow, Jessell, Hurd, Darrow, and Cohen (2017) conducted a survey which evaluated participant ratings after terminating medication. Participants recorded feeling content with their decision to terminate medication. Some participants in the study reported terminating medication at some point despite recommendation by their doctor to continue medication. This notes a disadvantage to the medical model. On the other hand, behavioral treatments are not implemented continually for the rest of someone's life, suggesting an effective alternative if someone is considering terminating pharmacological intervention.

Moreover, the absence of medication to reverse effects of TBI emphasizes the need for other intervention and rehabilitation strategies to treat symptoms associated with TBI. Despite the benefits and ease of implementation of pharmacological intervention, behavioral interventions should be further evaluated to treat behavioral symptoms associated with TBI.

### **Behavioral Pharmacology**

Within recent years, pharmacology and behavioral sciences have collaborated to create behavioral pharmacology, a relatively new and burgeoning subfield of ABA which focuses mostly on drug discrimination and drug self-administration research. Van Haaren and Weeden (2013) described behavioral pharmacology as “the branch of the experimental analysis of behavior that is dedicated to the study of the effects of drug administration and its interaction with other environmental variables on the behavior of individual subjects” (p. 498). The research

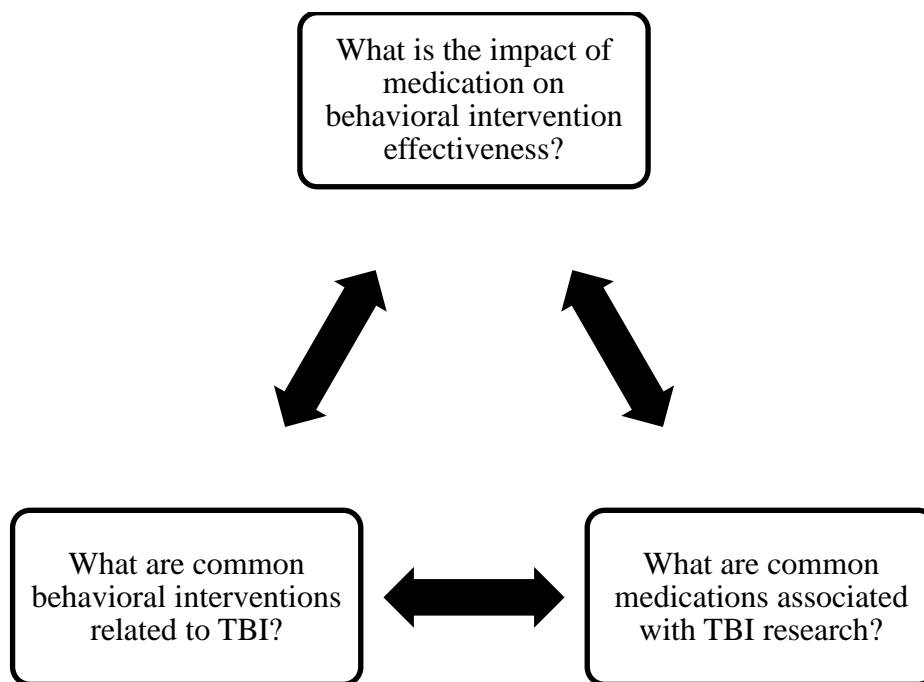
provided by behavioral pharmacologists has laid a foundation for expanding research on medication effects for individuals with TBI.

Burgio, Page, and Capriotti (1985) used a multiple baseline design across settings to compare dextroamphetamine, thioridazine, and contingency management effectiveness of decreasing various inappropriate behaviors across subjects such as aggression, self-stimulation, and inattention. Results of the study concluded the medications produced variable results across subjects while contingency management consistently decreased inappropriate behavior across all three subjects. Similar to Burgio et al. (1985), Miguel, Clark, Tereshko, Ahearn, and Zarcone (2009) evaluated medication versus behavioral intervention effects by examining effects of response interruption and redirection (RIRD) with and without sertraline in the treatment of automatically-reinforced vocal stereotypy. Results of the study indicated vocal stereotypy decreased with RIRD and appropriate vocalizations increased while sertraline had no effect on vocal stereotypy.

### Statement of the Problem

Applied behavior analysis has many practical uses for various fields. The dissemination of ABA into the field of TBI has fallen short. This dissemination is necessary when considering the shortcomings of pharmacological interventions for treating behavioral disorders. Maladaptive behavior is a common result of TBI that is typically treated through a medical model consisting of pharmacological intervention. Many social barriers arise when the maladaptive behavior interferes with daily living skills and social skills. These social barriers can be addressed through implementation of behavioral interventions to increase functional skills.

The aim of this paper is to evaluate both the limitations of the medical model and the implications for behavioral interventions for individuals with TBI. To properly address the aims of this paper, the following three interrelated questions are to be asked:



## Method

### Procedure

**Article identification.** A systematic search of the literature was conducted to identify articles published containing the following features: subjects with brain injuries, behavior analytic interventions, and/or medication effects. The PsycINFO, Online Wiley Library, and PubMed databases were used to search for relevant literature. The following keywords were used: applied behavior analysis, behavior analysis, behavior modification, behavior therapy, brain disorder, brain injury, medication, pharma\*, and pharmacology. With the previous criteria, 2,859 articles were identified. Articles were excluded if they did not meet any of the following criteria: if they used a design other than single-subject, if there was not both a baseline and treatment phase, if medication was not relevant to brain injury or behavior problems, if they were not peer-reviewed, if they were written in a language other than English, and if there was no quantifiable data. Once exclusion/inclusion criteria were met, 16 articles were reviewed.

### Data Coding

**Participant characteristics.** Participants examined were taking medications related to brain injury or behavioral problems. If participants were not taking medication, they still must have been diagnosed with a traumatic brain injury. Ages of participants varied from 16 years old to 54 years old.

**Medication categorization.** Medications examined were categorized by their class. Class categorization included antipsychotic, stimulant, selective serotonin reuptake inhibitor (SSRI), or dopamine agonist.

**Target response.** Behaviors were classified as targeted for either acquisition or reduction. The rationale for this identification was to determine which articles focused on

increasing a socially significant behavior or decreasing a problem behavior. Additionally, articles were classified based on topography of behavior; for example, hitting and yelling were categorized as aggression.

**Intervention characteristics.** Behavioral interventions were categorized as either antecedent or consequent interventions. Antecedent interventions included noncontingent reinforcement (NCR), environmental enrichment (EE), and any intervention including an elimination of an establishing operation (EO). Consequent interventions included differential reinforcement (DR), extinction (EXT), and punishment.

### **Review of Literature**

One of the earliest studies to examine the effects of a behavioral intervention on subjects with traumatic brain injury was conducted by Giles and Clark-Wilson (1988). Giles and Clark-Wilson implemented a behavioral treatment package consisting of verbal prompts and contingent reinforcement to increase functional living skills in four adults with TBI. The authors discovered the use of prompts and reinforcement to be effective in increasing independence for daily washing and dressing across all four subjects. Since then, the literature evaluating behavioral intervention effectiveness on brain injury has expanded significantly. However, very few studies have directly compared the effects of pharmacological interventions versus behavioral interventions in the TBI population.

### **Medication and Behavioral Intervention**

Cantini, Gluck, and McLean (1992) were among the first to evaluate the effects of replacing medication with a behavioral intervention. The authors decreased aggression and self-injurious behavior (SIB) in a 33-year-old male by reducing medication and using behavioral

interventions. Medication was reduced from five various medications to one anticonvulsant. During the first week, the subject's medication regimen consisted of four antianxiety and antipsychotic medications: lorazepam, haloperidol, lithium carbonate, and benztropine mesylate. During the final week, medication was reduced to 900 mg of carbamazepine to treat the subject's seizures.

In conjunction with medication reduction, a treatment package comprised of prompting, modeling, and verbal praise were used to increase appropriate behavior. Staff were trained to physically prompt behavior incompatible with aggression, model and verbally instruct deep breathing techniques, implement use of restraints during severe problem behavior, and praise appropriate behavior. A reduction in medication in conjunction with the treatment package was effective in decreasing problem behavior in an adult subject with a traumatic brain injury. Problem behavior remained at zero occurrences during the six-month follow-up. Although a formal FA was not conducted, direct observations of antecedent and consequent events during demand, social attention, and alone situations were analyzed to determine function; however, no function was identified.

It is difficult to evaluate if the reduction in medication or the behavioral interventions implemented were responsible for the reduction in problem behavior. An experimental design similar to that conducted by Burgio et al. (1985) could have appropriately addressed this issue. The authors would have to conduct a baseline phase, followed by treatment consisting of a reduction in medication, then revert back to baseline, implement another reduction of medication, revert back to baseline, and lastly implement the behavioral intervention. An experimental design following those guidelines would allow for a clear demonstration of behavior change due to the behavioral intervention (Cooper et al., 2007).

Freeman and High (2009) used prompting and a DRA procedure to decrease SIB. The authors used least to most prompting, verbal praise, punishment, and pharmacological intervention to decrease SIB in a 26-year-old female with traumatic brain injury. Prior to the study, the subject was taking six medications which were ultimately reduced to one medication. Precursor behavior was identified as a touch to the face and was used as the target behavior. A combination of both behavioral intervention and low dose of medication were effective in reducing subject SIB. Over the course of treatment, medication was decreased from 60 mg of fluoxetine per day to 2 mg of fluphenazine per day.

Similar to Cantini et al. (1992), Freeman and High (2009) did not separate pharmacological intervention and behavioral intervention. The same issue thus arises regarding determining which intervention was truly responsible for behavior change. When fluphenazine was reduced to 2 mg, an increase in SIB was noted during weeks 15 and 16 of treatment. The authors then increased fluphenazine to 4 mg and SIB decreased to zero. This finding might indicate both medication and behavioral intervention were responsible for behavior change. The authors did not conduct a follow-up; however, maintenance is suggested as problem behavior remained at zero for six weeks before treatment termination.

Another limitation of the Freeman and High (2009) study is their short baseline. The authors only included one data point of aggressive behavior prior to beginning treatment. In single-subject research, baseline typically lasts until a stable trend is displayed unless behavior is too severe, and intervention is needed immediately (Kazdin, 2011). Having multiple baseline data points allows for visual inspection of the trend of the behavior. Analyzing the trend of the behavior leads to an accurate prediction of the necessity for intervention.



The previous studies reviewed implemented an A-B experimental design, which is typical in ABA research if a return to baseline is not feasible or is unethical (Kazdin, 2011). Dixon et al. (2004) implemented a DRA procedure to decrease aggression in four subjects via a B-A-B experimental design. The B-A-B experimental design utilized by Dixon et al. (2004) is not standard in the ABA literature. Although not the standard, B-A-B experimental designs more effectively demonstrate experimental control than an A-B design due to the A-B designs lack of reversal. By including a reversal, intervention effects can be compared to baseline levels and intervention effectiveness can be evaluated.

Despite the advantages of the B-A-B design, there are disadvantages to this type of experimental design. Preintervention levels of behavior are not assessed in this design which can interfere with identifying the effectiveness of the treatment. (Cooper, Heron, and Heward 2009). The B-A-B design is typically used if a treatment is already occurring and cannot be removed due to ethical reasons (Kazdin, 2011).

Dixon et al. (2004) evaluated function-based treatments for four adults with brain injury following results of a functional analysis. Subjects engaged in inappropriate verbal behavior such as aggression and sexual utterances. Functional analysis results determined subject problem behavior was maintained by attention for two subjects and demand for two subjects. Differential reinforcement for alternative behavior was implemented for all subjects. During DRA conditions, appropriate vocalizations were reinforced by the experimenter and inappropriate vocalizations were ignored. DRA effectively decreased inappropriate verbal behavior of four adults with attention and escape-maintained problem behavior. Follow-up was conducted for one of the four subjects; during follow-up sessions, low rates of problem behavior maintained.

Inappropriate vocalizations remained at near-zero levels during DRA intervention, however, for one of the four subjects, there is a decreasing trend in appropriate vocalizations during both DRA phases in Dixon et al.'s (2004) study. This decreasing trend could be due to a lack of contact of the contingencies to emit appropriate vocalizations or other confounding variables not examined. To address this limitation, a criterion to contact opportunities to emit appropriate vocalization should have been predetermined at the start of the study. Including such a criterion would allow for a systematic evaluation of appropriate vocalizations. Although it was noted that subjects were taking medication throughout the study, effects of medication were not evaluated. Medication might have been a confounding variable responsible for the decreasing trend in appropriate vocalizations for one of the subjects.

The subjects in the study conducted by Schlund and Pace (2000) were also prescribed and actively taking medications, however medication effects were not evaluated in this study either, Schlund and Pace (2000) delivered systematic feedback to three adults with TBI. During feedback intervention, the experimenter and subject reviewed frequency of problem behavior followed by discussion of appropriate behavior. Results of the study indicate systematic feedback is effective in reducing problem behavior for individuals with brain injury. For two of the three subjects, feedback resulted in consistently decreased levels of problem behavior. Although intervention was effective, the authors did not model appropriate behavior while giving feedback.

In the ABA literature, behavior skills training (BST) is recognized as an effective intervention for teaching a new skill (e.g., Miltenberger et al., 2004, Dogan et al., 2017, Johnson et al., 2005). A BST intervention has four components: instruction, modeling, rehearsal, and feedback. Rather than measuring problem behavior, the percentage of correct trials in which a

skill is demonstrated is measured. Implementing the BST model also allows for an increase in an alternative, socially appropriate behavior. The use of a multiple baseline design across subjects, as used in the study, is not always feasible. During a multiple baseline design, subjects remain in baseline for extended periods and can result in ethical issues if problem behavior is severe (Cooper et al., 2007). Another advantage of implementing the BST model is that it does not have to be presented in a multiple baseline design.

Schlund and Pace (2000) noted that subjects were taking medication throughout the study, however, effects of medication were not evaluated. Two of the three subjects reported a history of drug abuse prior to beginning the study. Evaluating medication effects, such as a systematic reduction in medication similar to Freeman and High (2009), would potentially eliminate subject need for pharmacological intervention. Without an evaluation of behavioral intervention without pharmacological intervention, it cannot be determined if systematic feedback was effective independent of medication.

### **Behavioral Interventions for Individuals with TBI**

There is minimal literature base for the effects of medication on behavioral intervention effectiveness for adults with TBI. There is also little research evaluating the effects of behavioral intervention despite the potential influence of medication effects. In an earlier study, Cowley, Green, and Braunling-McMorrow (1992) used stimulus equivalence to teach three men with traumatic brain injuries to match names to faces. Their stimulus equivalence procedure was a match-to-sample training consisting of written names, dictated names, nameplates, and faces. The percentage of correct responding increased following match-to-sample training.

Additionally, the match-to-sample training increased three stimulus classes. Sidman, Wynne, Maguire, and Barnes (1989) suggested stimulus equivalence training is also effective in

increasing matching to other untrained stimuli. This research is essential to the TBI population as it indicates the implementation of a stimulus equivalence training will generalize to other stimuli. Memory loss is discussed as a symptom related to TBI with no medication available to treat it. Based on the findings of Cowley et al. (1992), stimulus equivalence training procedures should be further evaluated to increase recognition among individuals with TBI and generalization effects.

Tasky, Rudrud, Schulze, and Rapp (2008) used a reversal design to evaluate the use of choice to increase on-task behavior for three adults with TBI. During baseline sessions, subjects were randomly assigned a list of three tasks to complete. During treatment sessions, subjects were instructed to select three tasks from a list of nine and to complete the three selected tasks in any order. Choice increased on-task behavior to 100% for two of the three subjects. Tasky et al.'s study is one of the few to include a reversal within the treatment. Including a reversal effectively demonstrates experimental control and treatment effects (Cooper, Heron, & Heward 2007). However, treatment was only effective for two of three subjects. The authors noted the subjects had memory problems but did not evaluate the extent to which it would impact intervention. Conducting a discrimination training prior to implementing treatment might have resulted in higher percentage of on-task behavior for the subject with varied results. During discrimination training the subject is reinforced for engaging in a behavior in the presence of a specific stimulus (Cooper, Heron, & Heward 2007).

Similar to Tasky et al. (2008), Dixon and Tibbetts (2009) evaluated the effects of choice on preference between small immediate reinforcement and large delayed reinforcement for three subjects by conducting self-control training. The authors employed a multiple baseline design across subjects combined with reversals. During baseline, the subjects were instructed to sort

coins with no programmed consequences provided during an occupational therapy session. A choice baseline was also conducted where subjects were instructed to select a flashcard with the options either to do nothing and receive a small reinforcer or to do an activity for 10 times the mean level of baseline responding to receive a large reinforcer. Following both baselines, a self-control training was conducted. The self-control training consisted of providing subjects with three choices and corresponding progressive reinforcers. For example, if the subject opted to do nothing, they would receive a small reinforcer immediately. Alternatively, the subject could choose for either the experimenter or themselves roll a die and then do an activity for the duration identified by the roll of the die plus progressively increased duration and receive a larger reinforcer after a delay.

Results of this study concluded self-control training and choice were effective in increasing the duration of sorting time across all three subjects. An interesting finding of the study noted all three subjects selected the self-roll option rather than the experimenter roll option. Future research should evaluate subject preference for self-choice versus experimenter selected choice.

In another study in which an antecedent intervention was implemented, Ebanks and Fisher (2003) evaluated the effectiveness of antecedent prompts in the treatment of property destruction maintained by escape. The authors first conducted a functional analysis to determine the maintaining variables of problem behavior. Functional analysis results were undifferentiated, therefore the authors conducted a pairwise comparison of the demand and control conditions. Pairwise comparison results indicated property destruction to be maintained by escape from demands. When results of an FA are undifferentiated, a pairwise comparison is considered suitable to determine function (Iwata, Duncan, Zarcone, Lerman, & Shore, 1994). Following the FA, treatment was implemented consisting of a reversal design of consequent feedback sessions

followed by antecedent prompting. Antecedent prompting was more effective than consequent feedback in reducing destructive behavior to zero.

Wesolowski, Zenicus, McCarthy-Lydon, and Lydon (2005) evaluated the effects of least-to-most prompting and flashcards to increase correct responding to two subjects with speech disorders as a result of TBI. During least-to-most prompting treatment sessions, the subject was presented with a picture of a stimulus, such as a ball. If subject did not respond within 5 s, the experimenter provided the defining characteristics of the stimulus in the picture. If correct responding still did not occur, the experimenter provided a verbal prompt, such as “starts with bah.” If the verbal prompt failed to produce a correct response, the experimenter provided two options of what the pictured stimulus could be. Praise was delivered contingent on correct responding. Results of the study concluded least-to-most prompting with visual stimuli was effective in increasing percent correct of verbal responses across sessions.

Choice and prompting are antecedent behavioral interventions which can be used for various functions of problem behavior (Cooper et al., 2007). For problem behavior that is specific to a function, such as escape, demand fading is a suitable intervention (Piazza, Mose, & Fisher, 1996). Pace, Ivancic, and Jefferson (1994) used stimulus fading to decrease obscene verbalizations in a man with a traumatic brain injury. First, an FA was conducted to determine the maintaining variables of the obscene verbalizations. Functional analysis results indicated problem behavior to be maintained by escape from demands. Following the FA, treatment was implemented. The demand fading phase consisted of systematically increasing demands from a starting point of three demands per session. Demand fading was effective at reducing obscene verbalizations to zero. Although treatment was effective, there was only one data point during

the reversal phase. A single data point is insufficient in demonstrating intervention effects as it does not give a trend to depict if behavior is increasing, stable, or decreasing.

Alternatively, Travis and Sturmey (2010) evaluated the effects of DRA plus extinction on delusional statements for an individual with attention-maintained vocalizations. An FA was conducted prior to beginning treatment that determined problem behavior was maintained by attention. Treatment effectively reduced delusional statements while simultaneously increasing appropriate statements. The authors conducted follow-up sessions at 6 months, 1 year, 2 years, and 4 years. An increasing trend is noted across follow-up sessions for appropriate vocalizations while a decreasing trend in delusional statements is displayed.

Unfortunately, however, Travis and Sturmey (2010) failed to conduct staff training during their study. At the one-year follow up, a higher rate of delusional statements was noted. The authors noted this high rate could be due to the presence of new staff. A lack of effective staff training plus failed generalization to other staff could be responsible for this increased rate. The most common form of planning for generalization is the “train and hope” method, where generalization of behavior is not specifically programmed (Stokes & Baer, 1977). Training sufficient exemplars, as discussed by Stokes and Baer (1977), would be a suitable technique to ameliorate the subject’s failure to generalize. To train sufficient exemplars, multiple staff members would need to be trained on implementing DRA plus extinction procedures. While effective, this may become time consuming. Although Travis and Sturmey (2010) effectively evaluated the effects of DRA plus extinction to decrease delusional statements for an individual with TBI, currently no studies reviewed implemented DRA plus extinction for the target population while a pharmacological intervention was also implemented. Effects of medication on DRA plus extinction were unable to be evaluated.

Similarly, Wesolowski, Zenicus, and Rodriguez (1999) implemented an antecedent intervention, noncontingent escape, which was not evaluated in comparison to pharmacological interventions. While Pace et al. (1994) used demand fading to decrease problem behavior maintained by escape from demands, Wesolowski, Zenicus, and Rodriguez (1999) evaluated the effects of noncontingent escape on a fixed-time schedule for escape behavior at a vocational training facility. Noncontingent escape is another behavioral intervention effective in decreasing escape-maintained problem behavior (Vollmer, Marcus, & Ringdahl, 1996). During baseline, the authors posted appropriate break start and end times and instructed vocational instructors to ignore when subjects engaged in an unauthorized break and to deliver praise contingently on returning to work after an authorized break. During treatment, mini-breaks were incorporated to the regular break schedule. The results of the study indicated mini-breaks were effective in decreasing unauthorized breaks across subjects. Follow-up sessions were then conducted for two of the three subjects. During follow-up, the frequency of unauthorized breaks remained at zero. Despite not conducting an FA, the authors were still able to implement an effective treatment across all subjects.

As previously mention, noncontingent escape is an effective intervention for individuals with escape-maintained behavior. Although Treadwell and Page (1996) determined a subject to have problem behavior maintained by escape, an alternate intervention was implemented. The authors evaluated two different treatment packages in decreasing problem behavior for two adults with TBI. First, an FA was conducted for each subject. For Subject one, FA results indicated problem behavior was maintained by escape from demands. For Subject two, FA results indicated problem behavior was maintained by access to tangibles. The treatment package for Subject one consisted of guided compliance, behavioral momentum, and extinction. The



treatment package for Subject two consisted of functional communication and extinction. The treatment package for Subject one decreased problem behavior to low levels. The treatment package for Subject two decreased problem behavior to low levels, with a sudden increase occurring at session 21. The authors effectively evaluated idiosyncratic variables within the environment to create treatment packages.

Hegel and Ferguson (2000) wanted to evaluate the effectiveness of DRO to reduce aggressive behavior for an individual with a traumatic brain injury from a car accident 10 years prior. First, the authors administered a preference assessment. Next, during baseline, the subject was given a call bell, which they attached to his wheelchair, as well as a communication board. He was verbally instructed to use these for social interaction and told that he would receive social reinforcement contingent on their use. During the treatment phases, the subject was informed of the contingencies during DRO sessions. He was to use the call bell and communication board to gain access to attention from staff members, or otherwise sit quietly for the predetermined amount of time (i.e., the DRO interval). If no problem behavior occurred during the interval, the nurses were instructed to deliver praise. If problem behavior did occur, staff were instructed to (a) deliver a stern but brief reprimand and not speak to him further, (b) record the incident and time on the behavior checklist, and (c) reset the timer. During the day shift aggressive behavior remained low while problem behavior during the night shift was variable. Variability during the night shift could have been due to lower treatment integrity from the night shift nursing staff. Also, the behavior checklist conducted could have been supplemented by an FA to determine the function of problem behavior, which might have improved the results.

## **Discussion**

Franzel and Lovell (1987) proposed the use of behavioral treatment rather than traditional counseling methods to decrease aggressive behavior in individuals with TBI. In their article, the authors made explicit that they were not suggesting elimination of mental health counseling and pharmacological interventions, but rather recommending the use of behavioral interventions as a component of those treatments. In the years following the publication of this article, there was a notable increase in studies evaluating the use of behavioral interventions across various behaviors for individuals with TBI (Ylvisaker, Turkstra, & Coelho, 2005). After an intensive review of the literature, several conclusions became apparent: medications associated with TBI varied greatly, behavioral interventions associated with TBI are idiosyncratic, and few studies analyzed the effects of medication on behavioral intervention effectiveness. Expansion on these conclusions are discussed below.

During the initial screening process for articles to be evaluated, it was anecdotally noted that some studies evaluated medication effects in conjunction with a behavioral intervention but were unable to be included in this paper as they did not meet the inclusion criteria necessary. This was because the authors typically implemented a group design, did not provide clear operational definition of an observable behavior, and/or failed to include quantifiable data displayed in a single-subject experimental design. Ultimately, four studies were included which implemented a behavioral intervention for subjects taking TBI-related medication. Of these four studies, only two evaluated pharmacological intervention versus behavioral intervention, while no studies evaluated medication interference on behavioral intervention effectiveness (see Table 1 and Figure 2).

As displayed in Table 2, medications across studies were highly variable. The most common drug class noted were anticonvulsants ( $n = 6$ ). Anticonvulsants, also referred to as

antiepileptics, are used to treat seizures as well as agitated and aggressive behavior in individuals with TBI (Chew & Zafonte, 2009). Although effective, they can produce severe side effects, especially when taken with other medications. According to Chew and Zafonte (2009), anticonvulsants can delay rehabilitation and negatively impact cognitive function. While no studies were reviewed in this paper which directly evaluated the effects of anticonvulsants on behavioral intervention effectiveness, Cantini et al. (1992), and Freeman and High (2009) exemplified the positive effects of an anticonvulsant in combination with a behavioral intervention in decreasing problem behavior. Alternatively, for one of the three subjects in Schlund and Pace's (2000) study, systematic feedback did not reduce problem behavior to zero. The extent to which the anticonvulsant might have affected this outcome is unknown.

The second most common drug class noted across studies were antipsychotics ( $n = 5$ ). Similar to anticonvulsants, antipsychotics are also used to treat agitated and aggressive behavior in individuals with TBI (Chew & Zafonte, 2009). Although effective, antipsychotics have been noted as having adverse cognitive side effects on both human and animal subjects (Chew & Zafonte, 2009). The subject in Cantini et al.'s (1992) research was initially taking five antipsychotics, which ultimately was reduced to one anticonvulsant. The medication effects were not explicitly evaluated; however, behavioral treatment appears to be effective in conjunction with or despite pharmacological intervention. As displayed in Schlund and Pace's (2000) study, there appeared to be no interference of medication on behavioral intervention effectiveness, as systematic feedback was able to decrease problem behavior for the only subject on antipsychotics.

It was presumed that few to no studies would directly assess medication interference on behavioral intervention effectiveness, therefore it was planned to evaluate the effects of

medication on behavioral interventions across studies. Cantini et al. (1992), Ebanks and Fisher (2003), and Wesolowski et al. (2005) all implemented antecedent prompts as an intervention. The subjects in Cantini et al. (1992)'s research were the only ones who were prescribed medication while behavioral interventions were in effect. In comparing the three studies, antecedent prompting was effective in reducing problem behavior.

Cantini et al. (1992), Ebanks and Fisher (2003), and Wesolowski et al. (2005) were the only studies able to be directly compared. Other studies were unable to be compared directly because of the idiosyncratic target behaviors and interventions implemented. While the interventions and behaviors evaluated throughout this paper varied, aggression was a common behavior evaluated across eight of the sixteen reviewed studies (Cantini et al., 1992; Dixon et al., 2004; Ebanks & Fisher, 2009; Freeman & High 2003; Hegel & Ferguson, 2009; Pace et al., 1994; Schlund & Pace, 1999; Treadwell & Page, 1996). Aggression has previously been stated as a common and long-term side effect of TBI that is typically treated through anticonvulsants (Baguley, Cooper, & Felmingham 2006; Chew & Zafonte, 2009).

Although the main aim of this paper, to evaluate medication effects on behavioral intervention effectiveness were inconclusive, there were notable findings. Figure 1 displays the journals where studies were published, with seven studies being published in the *Journal of Applied Behavior Analysis* (JABA), five published in other behavioral journals, and four studies published in non-behavioral journals such as the *Journal of Head Trauma Rehabilitation* (JHTR) and *Brain Injury*. Articles published in non-behavioral journals used non-behavioral terms and often invoked mentalistic explanations, which is incompatible with a behavioral understanding of the problem.

With majority of articles being published in JABA and few in other non-behavioral journals, this notes a need for further evaluation and dissemination of behavioral interventions for brain injury. Cantini, Gluck, and McLean (1992) effectively demonstrated a decrease in problem behavior through use of behavioral interventions conjoined with a reduction in medication. Interestingly, this study was published in the journal *Brain Injury*. Upon visual inspection of their graphic data, problem behavior decreased to near zero 11 weeks after baseline. Although treatment was effective, the length of treatment required to reach near zero of problem behavior might compromise treatment integrity. Additionally, the intervention was conducted in an A-B design, which is a limitation because of a lack of demonstration of experimental control. Without a reversal, it is difficult to determine the reliability and effectiveness of an intervention. However, when evaluating drug effects, a reversal is not feasible due to either ethical concerns or drug interaction effects. By effectively disseminating and training others in ABA principles and techniques, perhaps an increase in effective treatments and treatment integrity will be seen.

In the field of ABA, an FA is an essential assessment to determine function-based treatment for an individual. The number of studies examined which included an FA are displayed in Figure 2. Problem behavior was mostly maintained either by attention or escape from demands and one subject exhibited problem behavior maintained by access to tangibles. Determining the function of problem behavior is imperative in ABA to develop functionally appropriate interventions. As discussed by Iwata et al. (2000), the identification of behavior function allows us to manipulate antecedent events, identify specific reinforcers, and use those reinforcers to strengthen alternative behavior while also identifying irrelevant variables.

### **Limitations**

The aim of this paper was to address potential limitations of the medical model in behavioral intervention effectiveness for adults with TBI; after review of the literature, there is not enough published, peer-reviewed research to address this question fully. It is possible not enough databases were searched to screen potential studies to include in this paper. Additionally, the exclusion criteria were extensive, which might be a variable contributing to the low number of studies evaluated.

### **Future Research**

Zimmerman and Polling (2016) discussed the need for further evaluation of the effects of psychotropic medication on behavior. Additionally, Van Haaren's (2016) research and this paper further the case for examining these effects. Van Haaren discussed the need for a further evaluation of the role of pharmacology in problem behavior and skill acquisition. Similarly, this paper noted the need for future evaluation of medication on behavioral intervention effectiveness in general.

Future research should also conduct FAs when developing a treatment for individuals with TBI. In two of the studies reviewed, medication was reduced following an effective behavioral intervention. To determine if behavioral interventions are more effective than pharmacological interventions, future research will need to compare the two treatments side-by-side with the same target behavior to decrease. For example, a reversal design can be implemented where medication is used to decrease aggression during the first phase. The second phase could be a behavioral intervention such as DRA plus extinction. To determine a function-based treatment, an FA would have to be conducted first. Based on the FA results, treatment can be chosen such as DRA plus EXT for attention-maintained problem behavior.

Evidently, applied behavior analysis is continually expanding into new fields. The global applicability of ABA has been apparent throughout the literature, and it is no different throughout the TBI research. However, there is an apparent need to evaluate the extent to which medication can interfere with the effectiveness of a treatment. Future research should further extend the findings of Miguel et al. (2009) to individuals with TBI by comparing the effects of behavioral intervention versus pharmacological intervention in decreasing problem behavior.

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## Tables

Table 1

### Studies Reviewed

Authors	Title	Participant Characteristics	Medication	Target Response	Behavioral Intervention
Cantini, Gluck, & Mclean (1992)	Psychotropic-Absent Behavioral Improvement Following Severe Traumatic Brain Injury	One male; 33 years old	Ativan, Haldol, Lithium, Cogentin, Tegretol	Decrease SIB	Antecedent; Prompting, Modeling  Consequent; Punishment, Praise
Cowley, Green & Braunling-McMorrow (1992)	Using Stimulus Equivalence to Teach Name-Face Matching to Adults with Brain Injuries	Three males; 30-57 years old	n/a	Increase match-to-sample	Antecedent; Stimulus equivalence
Dixon et al. (2004)	Exploring the Utility of Functional Analysis Methodology to Assess and Treat Problematic Verbal Behavior in Persons with Acquired Brain Injury	Four males; 20-61 years old	Zyprexa, Aricept, Depakote, Effexor, Adderall, Elavil, Inderal, Tegretol, Zoloft, Klonopin	Increase appropriate verbalizations	Consequent; DRA
Dixon & Tibbets (2009)	The Effects of Choice on Self-Control	Two Males, One Female; 16-18 years old	n/a	Increase on-task behavior	Antecedent; Choice
Ebanks & Fisher (2003)	Altering the Timing of Academic Prompts to	One male; 19 years old	n/a	Decrease destructive behavior	Antecedent; Prompting  Consequent;

Authors	Title	Participant Characteristics	Medication	Target Response	Behavioral Intervention
	Treat Destructive Behavior Maintained by Escape				Feedback
Freeman & High (2009)	Treatment of a Patient with Traumatic Brain Injury-Related Severe Self-Injurious Behavior	One female; 26 years old	Naltrexone, Valproic acid, Carbamazepine	Decrease SIB	Consequent; Punishment
Hegel & Ferguson (2000)	Differential Reinforcement of Other Behavior (DRO) to Reduce Aggressive Behavior Following Traumatic Brain Injury	One male; 28 years old	n/a	Decrease aggression	Consequent; DRO
O'Reilly, Green, Braunling-McMorrow (1990)	Self-Administered Written Prompts to Teach Home Accident Prevention Skills to Adults with Brain Injuries	Two females, two males; 18-37 years old	n/a	Increase home accident prevention skills	Antecedent; Written prompts
Pace, Ivancic, & Jefferson (1994)	Stimulus Fading as Treatment for Obscenity in a Brain-Injured Adult	One male; 49 years old	n/a	Decrease obscenities	Antecedent; Demand fading

Authors	Title	Participant Characteristics	Medication	Target Response	Behavioral Intervention
Schlund & Pace (2000)	Relations Between Traumatic Brain Injury and the Environment: Feedback Reduces Maladaptive Behaviour by Three Persons with Traumatic Brain Injury	Three males; 27-48 years old	Risperdal, Phenobarbital, Paxil, Dilantin	Increase compliance	Consequent; Feedback
Tasky et al. (2008)	The Use of Choice to Increase On-Task Behavior in Individuals with Traumatic Brain Injury	Three females; 21-47 years old	n/a	Increase on task behavior	Antecedent; Choice
Travis & Sturmey (2010)	Functional Analysis and Treatment of the Delusional Statements of a Man with Multiple Disabilities: A Four-Year Follow-Up	One male; 26 years old	n/a	Decrease delusional statements	Consequent; DRA, EXT
Treadwell & Page (1996)	Functional Analysis: Identifying the Environmental Determinants of Severe Behavior Disorders	Two males; 30-37 years old	n/a	Decrease SIB	Antecedent; Guided compliance  Consequent; FCT, reinforcement, EXT



Authors	Title	Participant Characteristics	Medication	Target Response	Behavioral Intervention
Wesolowski, Zenicus, McCarthy-Lydon, & Lydon (2005)	Using Behavioral Interventions to Treat Speech Disorders in Persons with Head Trauma	Two males; 16-44 years old	n/a	Increase appropriate verbal responding	Antecedent; Prompting
Wesolowski, Zenicus, & Rodriguez (1999)	Mini-Breaks: The Use of Escape on a Fixed-Time Schedule to Reduce Unauthorized Breaks From Vocational Training Sites for Individuals with Brain Injury	Three males; 16-24 years old	n/a	Decrease escape from tasks	Antecedent; Noncontingent Escape

Table 2

## Medications in Studies Reviewed

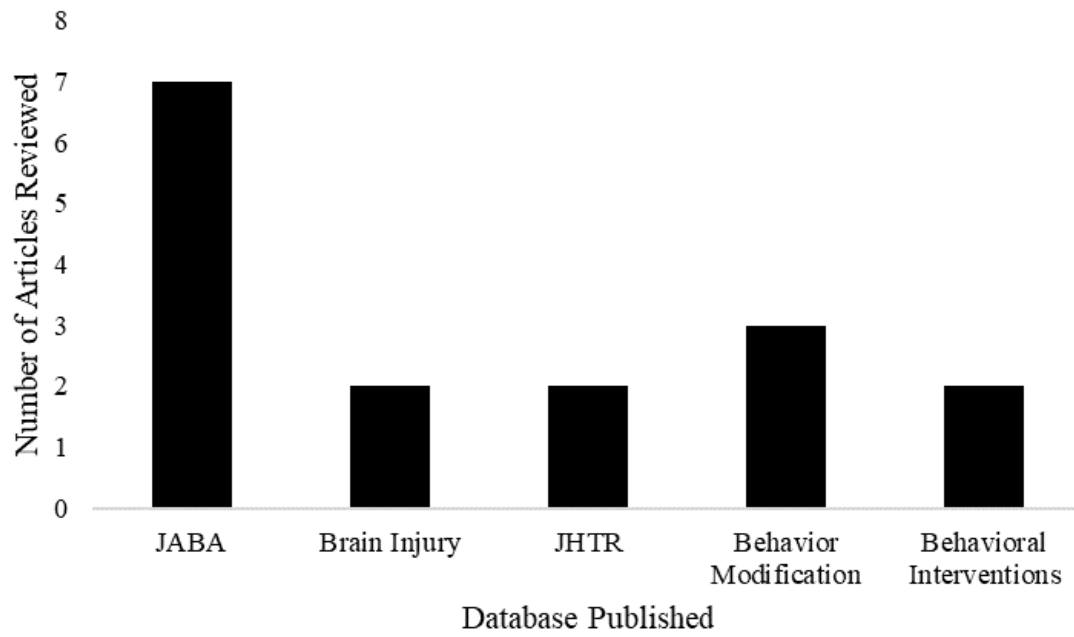
Medication	Drug Class	Brand Name	Common Uses	Side Effects
Amitriptyline	Tricyclic Antidepressant	Elavil	Treat mood problems, depression, reduce anxiety	Drowsiness, dry mouth, blurred vision
Benzotropine	Antipsychotic	Cogentin	Treats symptoms of Parkinson's disease (involuntary movements)	Drowsiness, dizziness, constipation, nervousness
Carbamazepine	Anticonvulsant	Tegretol	Prevent and control seizures	Nausea, vomiting, dizziness
Clonazepam	Anticonvulsant, Benzodiazepines	Klonopin	Prevent and control seizures	Drowsiness, dizziness, tiredness, increased saliva
Dextroamphetamine	Stimulant	Adderall	Treats ADHD, increase attention	Loss of appetite, weight loss, dizziness, headache
Diazepam	Depressant, Benzodiazepine	Valium	Treats anxiety, alcohol withdrawal, muscle spasms, seizure	Memory problems, nausea, muscle weakness
Donepezil	Acetylcholine Inhibitor	Aricept	Treat mild to moderate dementia caused by Alzheimer's disease	Nausea, vomiting, insomnia, tiredness
Fluoxetine	SSRI	Prozac	Treat depression,	Nausea, dizziness, anxiety

Medication	Drug Class	Brand Name	Common Uses	Side Effects
			panic attacks, OCD, bulimia	
Fluphenazine	Antipsychotic	Prolixin	Treat schizophrenia	Drowsiness, dizziness, nausea, loss of appetite
Haloperidol	Antipsychotic	Haldol	Treats psychotic disorders, aggression	Dizziness, lightheadedness, drowsiness
Lithium Carbonate	Antimanic Agent	Lithium	Treat bipolar disorder	Hand tremors, dizziness, nausea, lack of coordination
Lorazepam	Benzodiazepine	Ativan	Treat seizures	Muscle weakness, dizziness, slurred speech
Methylphenidate	Stimulant	Ritalin	Treats ADHD, narcolepsy, depression	Fainting, seizures, prolonged erection, twitching
Naltrexone	Opiate Antagonists	Revia	Prevent use of opiates	Nausea, headache, dizziness, anxiety, tiredness
Olanzapine	Atypical Antipsychotics	Zyprexa	Decrease hallucinations and agitation  Increase active participation in everyday life	Drowsiness, upset stomach, dry mouth
Paroxetine	SSRI	Paxil	Treat depression,	Nausea, dizziness, trouble sleeping

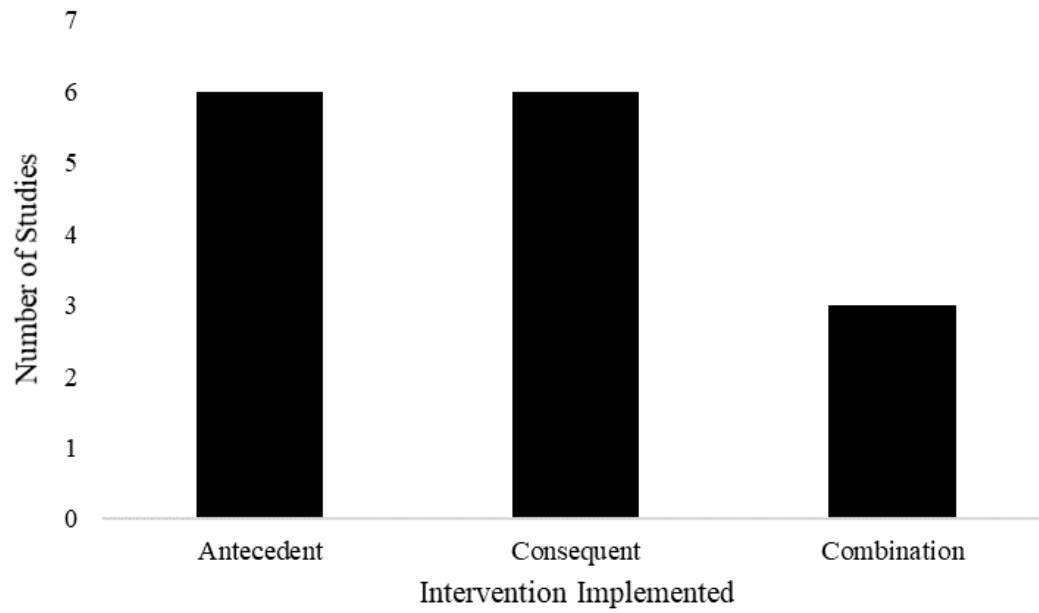
Medication	Drug Class	Brand Name	Common Uses	Side Effects
			panic attacks, OCD, anxiety	
Phenobarbital	Anticonvulsant	Luminal	Treats seizures and anxiety	Dizziness, drowsiness, excitation
Phenytoin Sodium	Anticonvulsant	Dilantin	Prevent and control seizures	Headache, nausea, dizziness
Propranolol	Beta Blocker	Inderal	Treats high blood pressure, shaking, irregular heartbeat	Dizziness, lightheadedness, tiredness
Risperidone	Atypical Antipsychotic	Risperdal	Treats mood disorder, irritability, hyperactivity, repetitive behavior	Weight gain
Sertraline	SSRI	Zoloft	Treat depression, panic attacks, OCD, anxiety	Nausea, dizziness, dry mouth, sweating
Topiramate	Anticonvulsant, Mood Stabilizer	Topamax	Treats epilepsy, migraines, bipolar disorder	Fainting, numbness, loss of appetite
Valproic Acid, Divalproex Sodium	Anticonvulsant, Depressant	Depakote	Treat various seizure disorders, Bipolar disorder, decrease impulsivity and aggression	Depression, dizziness
Venlafaxine	Serotonin- Norepinephrine Reuptake Inhibitor (SNRI)	Effexor	Treats depression, increase mood and energy	Nausea, drowsiness, blurred vision, trouble sleeping

(National Institute of Mental Health, 2016).

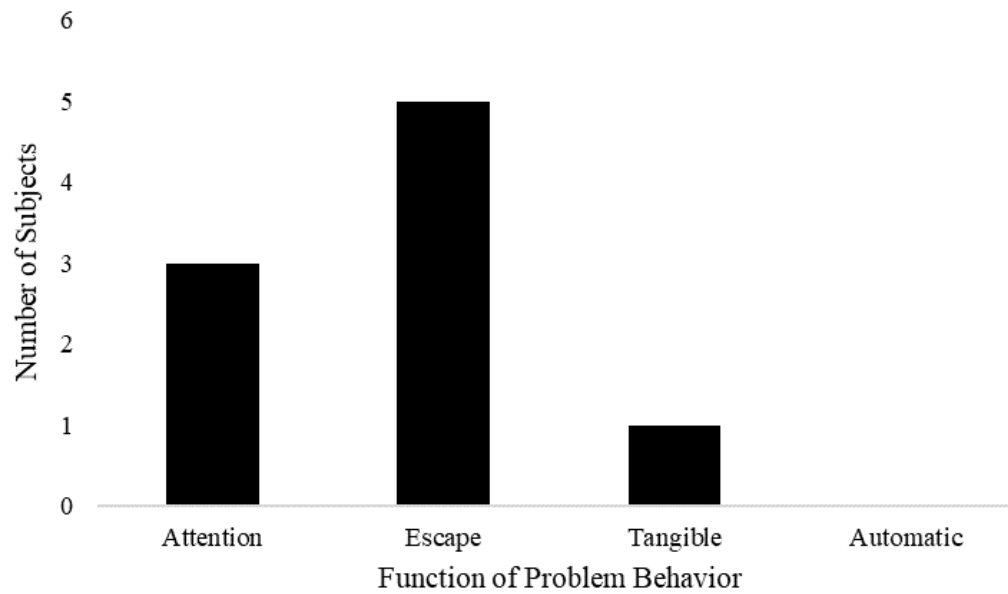
## Figures



*Figure 1.* Number of articles reviewed across various databases.



*Figure 2.* Types of interventions implemented across studies: antecedent, consequent, and a combination of antecedent and consequent.



*Figure 3.* Function of problem behavior as determined by functional analysis across number of subjects.