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Guiding Principles for the Use of Feedback in Educational and Psychosocial Interventions

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Abstract: Psychosocial and educational intervention approaches employ diverse treatment frameworks, most of which involve delivering some form of feedback to participants about their behavior. General conceptions of feedback are well-known to underlie mainstream therapeutic and educational approaches. Recently emerging 'smart' approaches also rely on feedback principles. However, little scholarship is available to stitch together evolving strands of feedback principles and no literature characterizes explicitly the diverse landscape of feedback practices employed in education or intervention science. This paper reviews intrinsic conceptions of feedback along with diverse cases of its use in intervention and education. Based on our consideration, we present a typology of feedback modalities that we hope will enrich the efforts of interventionists and educators to design treatment and educational frameworks incorporating feedback.

Keywords: *Design, feedback, framework, intervention, strategies.*

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Introduction

The practice of employing feedback to participants as part of psychological treatments and interventions has been a mainstay of care for decades. The options for developing feedback-based interventions are vast, with few resources available to guide researchers and clinician in use of feedback methods. The purpose of this current theoretical paper is to propose an organizational typology and framework to guide researchers in the evaluation and selection of feedback approaches in both the educational and psychological fields. Feedback itself can be as subtle as attending to intraindividual sensations, such as the cognitive recognition or affective experience that one has started or stopped an activity. Or, more commonly, feedback can be explicit in the form of a progress statement reflecting positive or negative statuses, such as in a letter grade or a sticker given to a child for completing a task. Most contemporary psychosocial interventions employ some kind of feedback, such as a summary of the objective details of an experience for a window of time (e.g., how often a child gets up from their desk during the school day), in light of certain tasks (e.g., number of math problems completed within a 5-minute time limit), and at times in light of a goal structure (e.g., whether a student met a monthly reading goal). Some elaborate forms of structured feedback include assessments tied to normative performance in a specific realm of a group such as a classroom (e.g., the percentage of peers who completed extra credit assignments), or with informed insights about the interpretation of the feedback, such as expert guidance (e.g., to help keep risk of alcohol problems to a minimum, college counselors may advise college student clients to keep drinking to 3 or fewer drinks at a time). In behavioral or therapeutic interventions, information presented to clients can take the form of motivational guidance (e.g., you said you would know when it's time to stop drinking on weeknights when it impacted college course attendance; this is your third week missing your morning classes), explicit rewards or consequences (e.g., earning points/stickers on a classroom board for task completion), specific remediative action (e.g., creating a social or academic safety net for student with disabilities), need for more dialogue for understanding (e.g., jointly exploring long-term antecedents and sequelae of a behavior), and so on. The overall effect these feedback experiences couched in one approach or another may be difficult to disassociate from feedback alone. For example, providing college athletes with the information that a urine test was negative for drugs is feedback, whereas providing monetary reimbursement for this is considered a reward, to the extent that the client desires the money. Clients/students may not disaggregate this

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transaction into its two components of feedback and reward. Similar challenges arose in behaviorist studies of humans and primates when researchers found it difficult to decouple cognitive feedback from an explicit reward or punishment.

Given the wide use of feedback in psychology, the expansion of using feedback in education settings, and the burgeoning number of ways in which people access information about their experience through interventions, devices, and other contexts, the concept of feedback and its diverse forms warrant further explication. We believe that anyone conducting research within an education setting (e.g., researchers, teachers, practitioners) can benefit from an inventory of the features of feedback approaches in designing interventions. Therefore, in this paper we have structured a typology of several overarching forms of feedback to help enhance modern intervention science. Important contexts for the use of feedback include substance use intervention, interventions surrounding disabilities, educational settings, and a range of other environments in which improvement of individual functioning is a goal. Information regarding various types of feedback and the intricacies of feedback approaches is heavily layered with both field-specific nomenclature and attendant concepts. The proposed typology aims to compile information across fields and across forms of feedback to provide researchers with a framework to build feedback-based interventions, on a continuum from basic to high complexity. Our typology extends from examples of feedback recorded in existing behavioral intervention literatures and through consideration of relevant contemporary scholarship on how feedback may be utilized to change health behaviors. We position, present and elaborate on the typology in four sections: (a) a selected review and distillation of feedback in earlier research paradigms, (b) consideration of contemporary scholarship on feedback deployment, (c) our proposed typology of feedback types, and (d) an exploration of how feedback might be operationalized in contemporary interventions and research studies. Our overall goal is to consolidate information on feedback which we believe could be of use in framing intervention research studies which rely on feedback components.

Literature Review

Early Notions of Feedback in Psychology

Feedback has long been thought of as a response given to an individual that may be a result of one's environment (often represented by experimental stimuli) and the concept has a clear historical locus in behaviorism. One of the earliest theories of behavior was proposed by (Pavlov, 2010), who suggested that any response (or behavior) can be elicited by a set of paired stimuli. Similarly, Watson's stimulus-response theory of behavior emphasized the association between a stimulus and an evoked response (Cooper et al., 2014). Skinner (1963) recognized that not all behaviors are equal in how they are influenced by stimuli, as some may be reflexive, and others may be purposeful. He argued that the responses demonstrated by early scientists, like Pavlov, were focused on reflexive behaviors. Skinner's operant conditioning highlighted the idea that behavior is selected by its consequences. Meanwhile, reinforcers have the ability to elicit reflective responses, but they are not purposeful (Skinner, 1963). Early behaviorist work largely placed value on feedback as a general notion, one which was largely enacted through explicit rewards or punishments that were finely crafted to reinforce specific learning goals, mostly in non-primate animals in laboratory settings. Any focus on the possibility of human participants receiving feedback on broader, real-life functioning was at best nascent. There have been some later, albeit infrequent, advances in considering feedback explicitly. Mangiapanello and Hemmes (2015) considered feedback from a behavior analytic lens, suggesting that giving feedback is one kind of operant conditioning procedure that may have value in interventions as an antecedent or precursor to the behavior being studied, rather than just a type of consequence post-behavior (Mangiapanello & Hemmes, 2015). Peterson (1982) outlined the need to delineate between various uses of feedback and the previously established conditioning and response theory procedures. Interestingly, Powers (1973) argued that stimulus-response theories in behaviorism could be better represented by a control-system model which characterizes the ways in which feedback alters behavior through feedback loops—recent work in computational areas (such as Dong et al., 2012) has reflected some viability for this approach, though not deriving from a behaviorist framework. Although limited in scope, these early notions of feedback provided the foundational kernel structure of stimulus-response, an idea that is indispensable to all contemporary feedback approaches.

Contemporary use of feedback remains very active in substance use research and interventions, cognitive research, and applied behavior analysis. Seminal works on feedback for behavior change include the work of Skinner (1963) and Cialdini et al. (1990). Personalized normative feedback was coined by Cialdini et al. (1990) when they found that providing descriptive norms about others' behaviors (i.e. whether others had littered in an area) reduced littering behavior (Cialdini et al., 1990). Midden et al. (1983) studied household utility use prior to feedback being a commonly used intervention tool. Participants received general information on reducing energy use, feedback on their own energy use, feedback regarding neighbors' energy use, or feedback on neighbor energy use plus monetary compensation for energy reduction. All were compared to a control group. For both electricity and natural gas use, providing comparative feedback along with monetary compensation resulted in the greatest reduction in use, as compared to all other forms of feedback. Individual feedback and comparative feedback still led to reductions, and the extra reduction in use for the comparative plus compensation group was not much greater than the other feedback groups (Midden et al., 1983). These findings demonstrate the efficacy of receiving feedback regarding a behavior, regardless of the type of feedback received. These early theories about the stimulus-response relationship were precursors to contemporary uses of feedback in psychosocial intervention which may be applied to education-based research/clinical practices.

Contemporary Uses of Feedback

Applied Behavior Analysis

Applied behavior analysis (ABA) is a field of science which uses experimental methods to identify variables that may be responsible for behavior change. This behavior change through ABA is meant to improve socially significant behaviors for those with autism spectrum disorder (ASD; Cooper et al., 2014). An example of this could be prompting a child diagnosed with ASD to utilize a picture menu in order to help them learn to express their desired meal when asked or to follow a picture schedule for daily classroom activities, with the help of reinforcement strategies. Mayer et al. (2019) suggest that feedback is an important element of applied behavior analysis. The feedback provided can be unintentional or planned positive feedback regarding the desired behavior, but both instances of feedback seem to help improve the learning process. The function of feedback may not only be for positive reinforcement though. Feedback can also be used to simply provide information about an individual's performance or to signal that a punishment will occur for an undesired behavior. As with the previously discussed research, feedback has been found to be most effective when it is clear and direct (Mayer et al., 2019). Contrary to the findings of Aljadeff-Abergel et al. (2017) who stated that feedback is most useful immediately before a new attempt at a task, Mayer et al. (2019) suggested that behavior is most easily changed when feedback occurs directly following a behavior. Although feedback is an effective tool, it may not be effective enough to change behaviors without the use of prompts, reinforcements, rationales, and goal-setting tasks (Aljadeff-Abergel et al., 2017; Mayer et al., 2019). Thiemann and Goldstein (2001) found that video feedback can be useful in teaching children with ASD how to engage in social communication with their peers when paired with visual cues about the targeted skills (Thiemann & Goldstein, 2001).

Another common form of feedback within ABA research is instructive feedback, which is typically used to teach an individual about a secondary target during a skills program (Grow et al., 2017). Grow et al. (2017) consider secondary targets to be skills or behaviors that are related to trained skills or behaviors that a child is not explicitly trained to complete but learns through the training process for the first target. Instructive feedback is used to teach a child a secondary response during the reinforcement phase from the first task, such as teaching a child about animal characteristics during a reinforcement task to review the names of animals. It was also found that play behaviors taught through instructive feedback generalized from the therapeutic training sessions to the general play area with other children (Grow et al., 2017). Leaf et al. (2017) found that instructive feedback has also been shown to be effective in teaching children diagnosed with ASD new concepts, both during one-on-one sessions and during group sessions with two other children. Not only did the children learn word-picture pairings better with the feedback present, they also learned the word-picture pairings assigned to the other children in the group when instructive feedback was used (Leaf et al., 2017). Wiskow et al. (2019) utilized verbal and visual feedback through a method called the Good Behavior Game in order to decrease the frequency of disruptive behaviors in classrooms. When children received verbal and visual feedback, they were most likely to reduce their disruptive behavior. Only providing verbal feedback still reduced disruptive behaviors, but not as drastically as combined verbal and visual feedback (Wiskow et al., 2019). Exploring the use of feedback in behavior analyst-type interventions may be helpful in understanding how to use multiple forms of feedback to change behaviors exhibited by children, especially children with special needs.

Cognition and Learning

Feedback also influences learning and performance on cognitive tasks in realms outside of ABA. Zaltz et al. (2017) found that children performed an auditory task significantly better when they were provided with external feedback as compared to when they did not receive any feedback. In fact, the children largely depended on the feedback to learn how to accurately perform the task. Young adults, on the other hand, do not seem to require external feedback in order to learn auditory perceptual tasks. This suggests that feedback may be a vital component in children's education (Zaltz et al., 2017). The importance of external feedback for young children is related to the fact that they do not have certain levels of knowledge regarding right or wrong answers, thus the feedback helps create these right/wrong typologies. When providing external feedback during cognitive tasks, information regarding accuracy and time spent on the task seem to be the most critical factors for improving performance (Cohen Hoffing et al., 2018). Additional research has found that performance on cognitive tasks, like definitional memory tasks, is best improved when the participant is provided with both feedback about the accuracy of their answers and with an example illustrating the definition being learned (Finn et al., 2018). When pairing students together on a learning task, performance outcomes greatly improve when feedback was provided regarding the accuracy of their outcomes. Students who received feedback about whether their solution to a problem was right or wrong were more likely to work collaboratively with their partner to find correct solutions on subsequent attempts (Asterhan et al., 2014).

The literature on the use of feedback in cognitive research also suggests that there are clear neurological responses to feedback information. An activation has been found to occur in the brain when feedback regarding a negative performance is provided, which was coined feedback-related negativity (FRN; Hajcak et al., 2006). Hajcak et al. (2006) found that participants playing a simulated gambling game experienced FRN anytime that there was negative feedback in the form of a visual cue of monetary loss, regardless of the amount of money lost. Those who experienced monetary

gain, or positive feedback, did not experience FRN (Hajcak et al., 2006). Understanding this response may be important for applying reinforcement and feedback strategies to learning theories.

Clinical Treatment and Substance Use Interventions

Feedback has become an important aspect of many intervention approaches within educational practice and research, but these feedback methods are also frequently utilized within psychological interventions and in the treatment of substance use. Feedback can be used to inform clinicians about client symptomatology and well-being, informing the direction of therapy and allowing clients and clinicians to alter their interactions, allowing for greater therapeutic progress and stronger rapport between clients and clinicians (Moltu et al., 2018). Clinicians tend to also use feedback as a way to track clients, ensuring they stay on track during treatment and as an alert system if the client deviates from the behavior change plan (Wise & Streiner, 2018). Lundahl et al. (2010) suggested that feedback is a useful addition to motivational interviewing, helping to increase a client's motivation to change by providing feedback about symptoms and progress (Lundahl et al., 2010). When treating adolescents and young adults with mental health and substance use symptoms, those who received feedback regarding their mental health symptoms had a significantly greater improvement in their symptoms compared to those not receiving feedback (Andersson et al., 2017). Injunctive feedback is a form of feedback that provides information regarding peer norms of approval about a specific behavior. Typically, when the norm is for peers to disapprove of a behavior, presenting that information to a client can help them towards decreasing the frequency of the negative behavior (Merrill et al., 2016). Ipsative feedback uses prior performance as the main feedback source, allowing individuals to be compared against themselves. Some research suggests that this type of feedback might actually help motivate clients or students due to the lack of negative comparison between oneself and a peer who is performing better (Hughes et al., 2014). These types of feedback methods are useful for monitoring client progress, building the therapeutic alliance, and helping clients to decrease negative or detrimental behaviors. These feedback methods may also be useful within classrooms or when interacting with students seeking university-based therapy, when building relationships with students is vital to improving behaviors.

Reducing alcohol consumption and misuse for college students has been an important goal in the feedback literature, as alcohol consumption may have long-term, pervasive consequences on their college experience. Personalized normative feedback (PNF) aims to correct perceptions of peer drinking behaviors in order to reduce how much alcohol an individual consumes (Lewis & Neighbors, 2006b). College students exposed to a PNF intervention, even those mandated for alcohol misuse, experience a reduction in alcohol consumption with both in-person PNF interventions and computer-based PNF interventions ((Lewis & Neighbors, 2015; White, 2006). PNF interventions may be useful in helping college students to reduce their overestimation of alcohol consumption by peers, may help students to decrease their consumption intentions, and reduce actual alcohol consumption (Hummer & Davison, 2016). White et al. (2008) found that students mandated for substance use problems showed a significant decrease in alcohol consumption two months and seven months after receiving a PNF intervention (White et al., 2008). Bernstein et al. (2018) found that students who received text-message based feedback regarding the number of drinks the participant intended to consume, the peer norms regarding 21st birthday alcohol consumption, and the impact of intended alcohol use on blood alcohol content, tended to report consuming fewer drinks if they also perceived the peer norms around drinking rates to be low (Bernstein et al., 2018). Although reduction of alcohol consumption is important for college student populations, PNF has also been used to reduce alcohol use among young veterans, with significant reductions in alcohol consumption reported one month after PNF intervention, compared to their control group counterparts (Pedersen et al., 2017). The feedback methods described aiming to reduce alcohol consumption or opioid use may be applied to other substances, such as smoking cigarettes, and may be effective online or during in-person treatment (Borrelli et al., 2017; Dallery et al., 2013, 2015; Rash et al., 2018). Use of these methods for any substance may be important for supporting college student health and success.

Biofeedback

Biofeedback can largely be defined as a group of measurements gathered using electronic devices that are given to the participant or client in order to improve physical and/or mental health symptoms (Schwartz & Andrasik, 2003). This type of feedback is frequently deployed as an intervention for psychological problems that manifest in physical ways, such as stress. Stress is a psychological symptom that can manifest with increased heart rate, muscle tightness, or other physiological symptoms. Common forms of biofeedback used in stress reduction interventions include feedback on heart rate, blood pressure, breathing rate, muscle tension, and salivary cortisol (De Witte et al., 2019). Gross et al. (2018) measured individuals heart rate, breathing pace, and galvanic skin response in order to provide biofeedback that would allow the participant to lower stress and better regulate their emotions during a high stress event. Participants were provided with real-time biofeedback and asked to pace their breathing in a way to reduce their symptoms, resulting in decreased symptoms and decreased feelings of stress (Gross et al., 2018).

Although biofeedback is most commonly used to reduce psychological symptoms like stress, there seems to some use for biofeedback in substance use reduction, but utility of feedback in this way is still questionable. Bize et al. (2007) conducted a systematic review examining the use of biomedical feedback in smoking cessation efforts, finding that

providing information about the biomedical risks of smoking does not increase an individual's adherence to a smoking cessation program (Bize et al., 2007). Brunette et al. (2013) provided biofeedback about the carbon monoxide levels in participants' breath, hypothesizing that the feedback may help motivate participants to quit smoking. In accordance with previous findings, there was no significant difference in cessation for those who received biofeedback as compared to those that received no feedback (Brunette et al., 2013). Eddie et al. (2015) argued in favor of the possibility of biofeedback helping to treat substance use disorders, as there are clear physiological reactions to feelings of craving and emotion dysregulation, which are often associated with substance use. They propose that tracking heart rate variability and providing biofeedback on those factors to clients would allow them to monitor their physiological reactions to a craving, thus allowing them to calm that response and eventually reduce their substance use frequency (Eddie et al., 2015). The use of biofeedback seems to be a viable option in treatment of substance use and potentially other behavioral interventions, but the broad application of biofeedback methods warrants continued research, especially when considering use of biofeedback within education settings.

Theoretical Framework

Our review of the literature regarding feedback in its various forms and deployments led us to formulate a theoretical framework through which we might better define, build, and implement feedback strategies in research and in practice. Feedback is a tool with utility across fields, which can take on a variety of forms and has successfully been used to target a variety of behaviors. Over these areas, three general conditions emerged as central to assigning feedback types: scheduling, generalizability, and the number of risk behaviors being targeted by the intervention.

Scheduling

Scheduling refers to how often feedback is occurring during any given intervention. Research may use feedback during a single session, across multiple timepoints, or even daily. Lewis et al. (2014) provided a single-session PNF intervention to college students, finding reductions in quantity and frequency of alcohol consumption and reductions in alcohol-related risky sexual behaviors separately (Lewis et al., 2014). Most of the research regarding feedback in the context of drug addiction provides feedback across multiple timepoints (Schottenfeld et al., 2005). Ecological momentary assessment (EMA) is a research methodology that allows for a large amount of data to be collected on one individual. Depending on the study design, an individual will be prompted to complete short assessments regarding substance use, location, affect, or other pertinent factors. This frequent input of information allows researchers to create interventions that include tailored feedback that focuses on specific behavior related factors for a single person. For example, feedback can be provided regarding the times of day or location where an individual most often stops to have a cigarette or an alcoholic beverage (Shiffman et al., 2008). Scheduling may also refer to the timing of feedback in relation to a behavior. Aljadeff-Abergel et al. (2017) found that providing feedback to teachers about their performance was most useful in adjusting their behavior when given immediately prior to the next teaching attempt, rather than directly after their first teaching attempt. If performance feedback was given immediately after the teaching task, behaviors during the next attempt were changed significantly less, and sometimes not changed at all (Aljadeff-Abergel et al., 2017). Scheduling and timing of feedback seems to vary in the literature and having a stronger understanding of the impact of timing is important for further intervention development.

Target Generalizability

Target generalizability can be thought of in terms of two types of outcomes that feedback is targeting. These two outcomes include (a) overall wellness and (b) specific behavior change. Feedback seems to have some utility in monitoring and changing general well-being of individuals. Specifically, some research suggests that therapy may progress more effectively when patients receive feedback regarding how their progress impacts overall life functioning and when clinicians are able to receive feedback regarding early warning signs about worsening symptoms (Moltu et al., 2018). The use of feedback in ABA provides guidance for skill building and social functioning for those diagnosed with ASD, thus using feedback to influence general well-being and functioning of individuals experiencing that course of treatment (Lewis & Neighbors, 2015). For most feedback-based interventions, the impact on general wellness tends to be less of a focus as compared to feedback in the context of behavior-specific or risk-specific outcomes. Visual performance feedback has been implemented to insight behavior change in students while in the classroom and to help teachers engage more effectively with students during task completion by increasing behavior-specific praise ((Hagermoser Sanetti et al., 2013; Hawkins & Heflin, 2011) As discussed previously, there are a variety of interventions using feedback (e.g., PNF interventions, gender- or age-specific interventions) to reduce specific substance use problems, including alcohol consumption, smoking, and illicit drug use (Borrelli et al., 2017; Lewis & Neighbors, 2006a, 2007, 2015; Schottenfeld et al., 2005). Although the goal of feedback tends to be the creation of generalizable, relatively simple interventions, group or goal specific feedback can be helpful in its own way. Understanding how to shift target generalizability of a feedback intervention allows for creation of specialized goals which may increase efficacy of these interventions, but broad target generalizability may allow for a stronger focus on wide-ranging behavior change.

Single or Multiple Behavior Targets

The number of risk behaviors targeted by feedback interventions and the behavior or setting of interest varies in the literature from a single behavior to multiple, related behaviors. These single or multiple behavior targets may be related to education, psychology, substance use, or a wider array of research areas. Alcohol consumption as a target of feedback interventions has been widely studied on its own, with the context of alcohol consumption varying to include mandated college students, those approaching their 21st birthday, college students that are engaging in risky sexual behavior, and veterans (Bernstein et al., 2018; Hummer & Davison, 2016; Lewis & Neighbors, 2015; Pedersen et al., 2017; White et al., 2008). Contingency management, within which feedback is a vital component, has been studied to reduce cocaine and opioid use (Miguel et al., 2017; Schottenfeld et al., 2005). Reducing cigarette smoking through the mechanism of feedback has been studied in both the homeless population and in parents with asthmatic children (Borrelli et al., 2017; Rash et al., 2018). Ahn and Lebowitz (2018) found that feedback targeting obesity may influence an individual's food choices, such that participants who were given positive feedback about their genetic propensity for obesity were more likely to choose healthy food options and to consider healthy diet and exercise habits to be important (Ahn & Lebowitz, 2018). Although targeting a single risk behavior is important, these behaviors do not occur in isolation. Some research has begun to examine how feedback may influence multiple behaviors at once. Schottenfeld et al. (2005) used contingency management to reduce cocaine and opioid use both as separate drugs and through a dual-use perspective. Lewis and Neighbors (2015) attempted to reduce both alcohol consumption and alcohol-related risky sexual behaviors together, but only saw reductions in college students that viewed personalized normative feedback for a single behavior, either alcohol or risky sexual behavior (Lewis & Neighbors, 2015).

These principles are meant to provide options to researchers and practitioners regarding ways in which data can be gathered to inform feedback and/or ways in which feedback can be provided to participants/clients/students.

Proposed Feedback Typology

We believe that the guiding principles covered in the previous section inform a typology of feedback very well. Organized into four levels of increasing complexity, our typology may be useful in the creation and implementation of clinical interventions or classroom-based interventions and in framing research studies around feedback. Based on our review and consideration, four main types of feedback predominate: basic feedback (e.g., number of books read in one month), comparative feedback (e.g., how a student's recent reading test score compares to their previous reading test score), guided feedback (e.g., monitoring books read per month and reading test scores to determine which books best suit the needs or interests of a particular student), and enhanced feedback (e.g., using online system to track reading ability and achievements, tailored for individual students, which increases complexity of books or tests over time with achievement). These four levels of feedback were derived from a key set of features, including the ways in which the information is captured, the ways in which information is compiled prior to dissemination, or the complexity of information provided to the individual. *Basic feedback* relies on simple counts or averages of data, provided to the individual without much compilation besides summaries of the data over a given time period. *Comparative feedback* compiles information from more than one source (e.g., the individual of interest and the entire class of 8th grade students) in order to provide the individual with a figure to compare their own performance against. *Guided feedback* continues to utilize data from multiple sources but utilizes multiple sources of data to shift the goals for the individual based on their achievement of previous goals. *Enhanced feedback* takes into account multiple sources of data and shifting goals but uses advances in technology to continue pushing the individual towards goal achievement.

Depicted below (Figure 1) is our proposed hierarchy of the four main types of feedback, beginning with the most basic on the bottom and ending with the most complex and elaborative on top. With increasing complexity, the simpler forms of feedback are likely utilized to inform the more complex feedback methods, but the full architecture of the feedback generating process may not always be presented to the individual receiving the feedback intervention. In some cases, there may be an additive nature as one builds more complex feedback mechanisms as demonstrated in the examples above, but one can develop a feedback intervention at a more complex level without necessarily utilizing the basic feedback options. The sections below elaborate on each part of the typology.

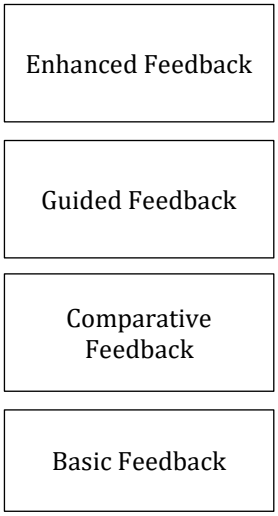

Figure 1. Hierarchy of Four Main Types of Feedback

Basic Feedback

Basic feedback encompasses the information provided to clients or participants that does not have an explicit interpretive or comparative element (see Figure 2). This information can be in the form of simple data points or data driven information, such as number of steps taken in a day or number of math problems completed by a student within a time limit. Being able to provide summarized information about a client's therapeutic process, symptoms, or risk levels during treatment is a common form of this basic level of feedback (Andersson et al., 2017; Moltu et al., 2018; Wise & Streiner, 2018). Visual performance feedback and video self-monitoring provided to teachers simply regarding the number of behavior-specific praise statements given to a student during task completion has been found to increase the number of behavior-specific praise statements used during post-intervention tasks (Hawkins & Heflin, 2011). Another common form of basic feedback is biofeedback, providing summarized data regarding physiological reactions related to psychological or physical symptoms (Schwartz & Andrasik, 2003). Although these types of feedback are useful in helping individuals change behaviors, examining more complex feedback seems to be of importance.

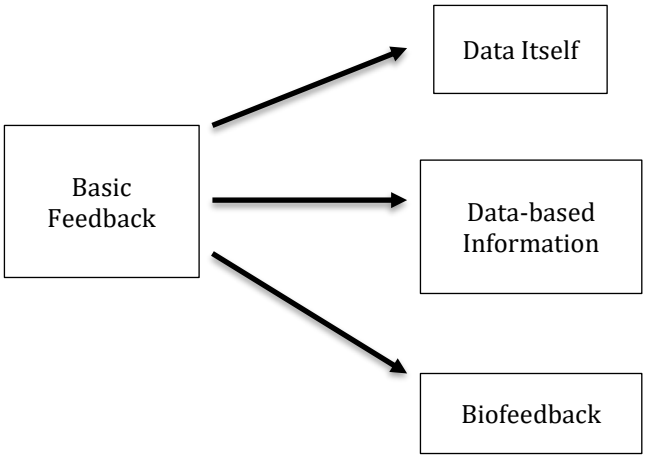

Figure 2. Basic Feedback Typology

Comparative Feedback

Comparative feedback allows us to compare behaviors, symptoms, and outcomes to others, standards, and ourselves (see Figure 3). Ipsative, injunctive, and personalized normative feedback all fall into this category. Ipsative feedback is a way to compare one's own progress on a task, using previous performance as the primary form of feedback (Hughes et al., 2014). This type of ipsative feedback has been shown to improve motivation for college students engaged in distance learning, with some researchers suggesting that implementation of ipsative feedback and grading as university standards may improve academic performance (Hughes, 2011; Hughes et al., 2014). Comparative feedback can also involve comparisons against other groups, with injunctive feedback being a specific comparison between one's own behaviors and norms regarding peer approval (Merrill et al., 2016). Lewis et al. (2014) used PNF to reduce alcohol consumption in college students by providing feedback regarding drinking norms for student peer groups. There were also significant effects of PNF on the participant's perceptions of drinking behavior norms, which mediated their own alcohol use behaviors post feedback viewing (Lewis et al., 2014).

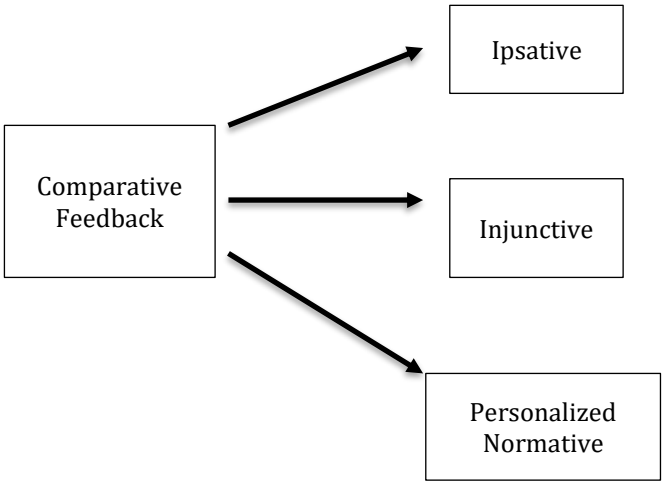

Figure 3. Comparative Feedback Typology

Guided Feedback

The third level of feedback becomes increasingly more complex, gathering information from the first two levels and compiling that information into some type of feedback intervention, typically providing more in-depth information than the previous levels of the typology (see Figure 4). Guided feedback can be provided to individuals (whether that be clients, teachers, students, etc.) without providing information from the previous levels of the feedback hierarchy, but the simpler forms of feedback typically inform these more complicated forms. Feedback in the context of Applied Behavior Analysis may be considered a form of guided feedback as information provided back to the client or to parents is often catered towards very specific tasks or behaviors for specific individuals (Cooper et al., 2014). Personalized, tailored feedback regarding physical activity has been found to improve physical activity during the school day for middle school students (Haerens et al., 2007), with additional research needed to explore broader impacts of this type of intervention.

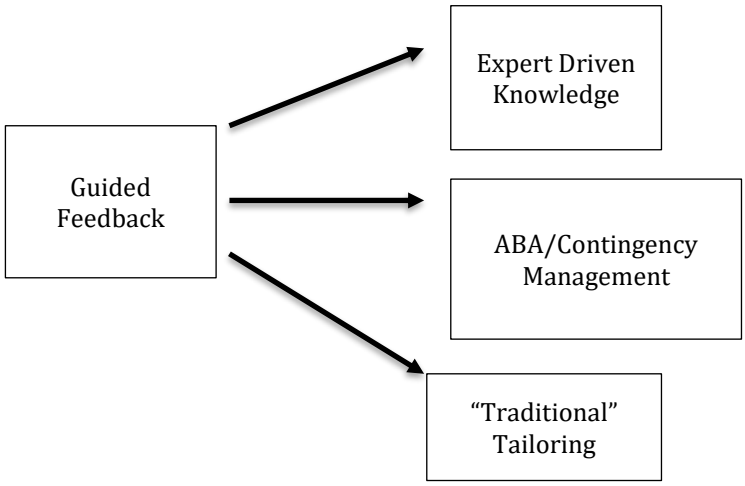

Figure 4. Guided Feedback Typology

Enhanced Feedback

The highest-level feedback in this typology (see Figure 5) is largely represented by expert systems and smart feedback systems, designed to gather specific information about an individual's symptoms and provide specific, targeted feedback to reduce risk behaviors. Riley et al. (2011) reviewed mobile health interventions, finding that mobile feedback can be useful in assisting weight loss and dieting attempts, treatment adherence, and disease management. Mobile health interventions to engage individuals in smoking cessation efforts seem to work, but this association is under-researched (Riley et al., 2011). Adaptive feedback and smart feedback have been combined to explore whether self-regulated learning skills can be improved when a socially assistive robot provides adaptive feedback during learning tasks (Jones & Castellano, 2018). The enhanced feedback space will likely continue to develop as AI systems are enhanced and implemented more often in educational settings. These methods at the most advanced level may have emerging applications in education settings given the rise of AI technologies and ways in which feedback may be tailored to student or teacher outcome improvement.

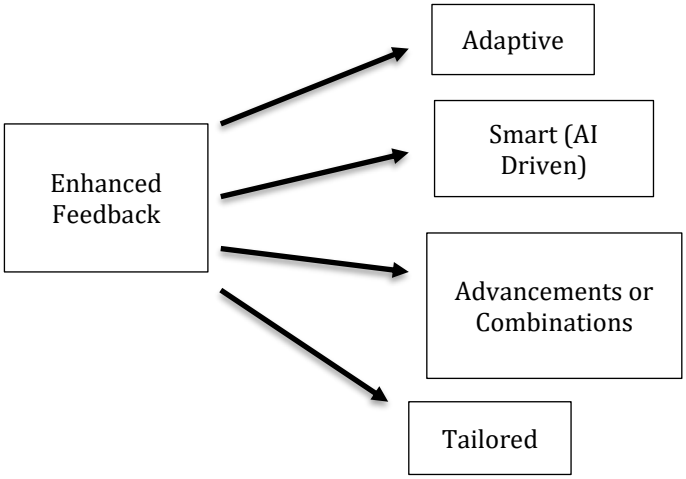

Figure 5. Enhanced Feedback Typology

Components of Feedback

Alongside consideration of the feedback typology described above, another vital component to consider when designing feedback is the goal structure and function. Hattie and Timperley (2007) suggested that feedback works to answer three main questions; what is the goal, how does one reach that goal, and what happens after the goal is reached (Hattie & Timperley, 2007). Alvero et al. (2001) examined how consistently various forms of feedback produce desired results, whether that be a reduction or increase in a specific behavior. Important characteristics suggested by Alvero et al. (2001) included the source of feedback, the medium feedback was presented through, frequency of feedback, characteristics or involvement of participants receiving feedback, level of privacy when receiving feedback, and the feedback content (Alvero et al., 2001). Figure 6 provides a proposed guide by which to design feedback based on the feedback characteristics suggested by Alvero et al. (2001) together with the three questions to be answered by feedback, as presented by Hattie and Timperley (2007). This figure depicts how the characteristics of feedback come together to form a complex package of information that can be applied to the three questions addressed by feedback.

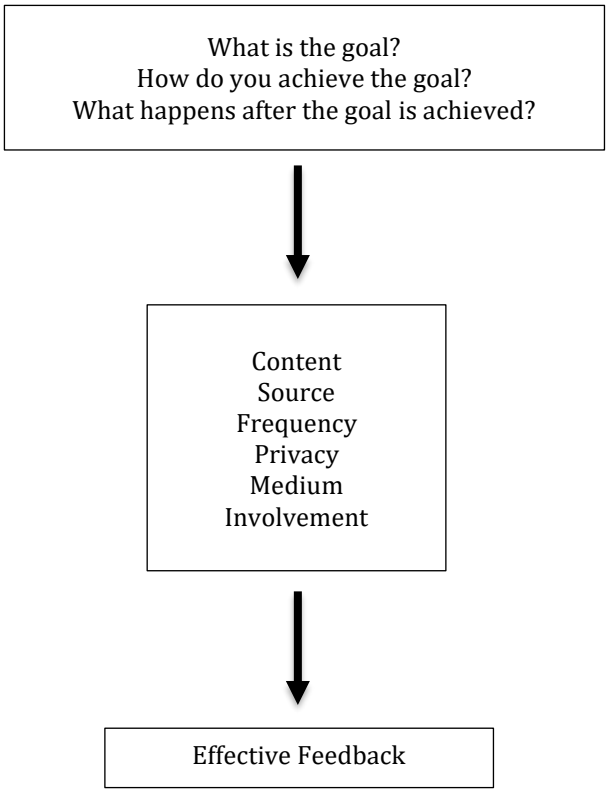

Figure 6. Designing Effective Feedback

Conclusion

Direct consideration of feedback is critical for educational, psychological, and health behavior inquiry and practice. There is potentially great impact yet to be realized in the enhancement of educational strategies based on refinements of feedback components in programming as they may drive teacher and student outcomes. Our typology adds a formal structure to what is otherwise, of necessity, informal and *ad hoc* development of feedback interventions. Systematic and methodological design of feedback is crucial for effective feedback-based research and interventions. As discussed earlier, work by Skinner (1963) and other behaviorists laid a foundation for feedback in psychology and subsequent work in feedback interventions has increased in complexity over time. However, an overarching contemporary structure for feedback has not evolved linearly out of behaviorism or other behavior change fields (Olencevicius, 2019). Rather, much like in the process of cell differentiation, we believe that core ideas of feedback have differentiated into more specific forms which, at best, yield vague backward interpretability into behavioral notions of feedback. We hope that our typology provides a foundation for selecting and incorporating feedback into modern school-based interventions. In particular, we hope that it will enable researchers to optimize their selection and design of feedback for greater impact in their studies or in their classrooms. There is a great deal of work to be done to enrich dialogue about approaches falling into each type of feedback with accessible concepts and nomenclature supportive of broad scientific and applied dialogue over interventions. How best to design feedback within each type for diverse clients, students, or study participants is another substantial challenge.

Recommendations

Future research should address ways to isolate individual types of feedback and their effects, separate from other components of intervention studies. Knowing how feedback functions separately from various intervention components, such as education, rewards and punishments, or interactions with research staff, is important for the improvement of this typology. It may also be useful to expand the typology to understand how feedback may influence the formation of negative behaviors. Continuing to refine this typology may allow the field to refine feedback enhancements, thus improving its utility within empirical studies and intervention work. Additionally, use of this typology in an education or therapeutic setting by teachers, therapists, or specialists may support development of positive outcomes for students/clients. The methods of feedback included in this typology may provide guidance for practitioners seeking ways in which they may gather information to present to clients to actively monitor progress, outcomes, and teach self-monitoring skills to their clients. Practitioners may find themselves deploying a variety of feedback methods included in this typology based on the desired intensity of tracking behaviors, the depth of involvement of their client, and the amount of time available for behavior modification.

Limitations

Some issues around feedback that need to be further explored include accuracy and ethical standards. As reviewed previously, there are a wide variety of behaviors that are targeted in interventions utilizing feedback. Current research findings are unclear as to the amount of data necessary to deal with the various behaviors being studied. Research must also be conducted to understand the impact of noisy data, or data across a great number of time points. For example, if we learn that conclusions can be made about a behavior after collecting data over a certain number of days, how should we interpret the data before reaching that number of days? Additional considerations regarding data collected includes the ethical obligations tied to potential findings in intensively collected health data. For example, research protocols must consider how to handle potential findings of genetic or chronic diseases, as an individual has a right to know and a right not to know these types of information. We must also consider if there are any obligations to report findings of a sensitive nature to entities besides the study participant, such as the individual's family, public health authorities, school administrations, etc. Ethical considerations around privacy, consent, and beneficence are often of concern for big data research, and these concerns apply when collecting any level of information from clients or participants and providing them with feedback to direct behavior change (Zimmer, 2018).

In summary, feedback is an important tool in health behavior and educational research, but there are still many unknown attributes that should be explored in order to use feedback to its full potential. This theoretical typology is a call to further explore the potential that lies in feedback approaches and to work towards a broader understanding of how to effectively elicit behavior change through their use.

Authorship Contribution Statement

Shuster: Conceptualization, design, article acquisition, analysis, writing, critical revision of manuscript, final approval. Walls: Conceptualization, design, writing, critical revision of manuscript, supervision, final approval. Stein: Conceptualization, critical revision of manuscript, final approval.

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