6 Optimizing treatment and instruction: Implications of a new theory of disuse

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With few or no exceptions, the goals of both treatment and instruction (or training) are long-term goals. In the case of instruction, we would like the conditions of instruction and practice to yield knowledge and skills that are durable and flexible – that is, knowledge and skills that are not only accessible within the instructional context, but that are also accessible in the various post-instructional real-world settings to which they are applicable. In the case of treatment, we would like therapy to be structured in a way that produces long-term changes in behaviour – that is, changes that last beyond the end of treatment and are not confined to the treatment context.

Knowledge and skills acquired during instruction, however, often prove to be neither durable nor flexible. Individuals who perform well at the end of instruction frequently perform poorly at a later time when it really matters, especially if a prolonged period of disuse of that knowledge or skill has intervened, or if the post-instructional environment differs – even superficially – from the instructional environment. Similarly, changes in behaviour that are evident during treatment are often short-lived after treatment, or fail to transfer to the real-world settings in which they are most needed, or both. Individuals who overcome fearful responding during treatment, or appear to make progress in overcoming some other problem, frequently suffer a return of that fear or problem as time passes after treatment (e.g., Clark, Salkovskis, Hackmann, Middleton, Anastasiades, & Gelder 1994; Craske, Brown, & Barlow, 1991; Heimberg, Salzman, Holt, & Blendell, 1993; Ost, 1996; and see Craske, 1999, and Rachman, 1989, for reviews).

Learning versus performance

Why are programmes of instruction and treatment often less than successful in achieving the long-term goals of instruction or treatment? One reason, as we and our colleagues have argued elsewhere (e.g., Bjork, 1994, 1999; Bjork & Bjork, 1992; Christina & Bjork, 1991; Jacoby, Bjork, & Kelley, 1994; Schmidt & Bjork, 1992; Simon & Bjork, 2001), is that teachers, trainers, and therapists are at risk of assuming that *performance* during instruction, training, or treatment is a reliable index of *learning* – that is, that performance during instruction provides a valid basis for judging whether the relatively permanent changes that will support long-term performance have or have not taken place. In fact, such performance is often *not* a reliable index of learning.

The need to distinguish between learning and performance traces back to the heydays of learning research – the 1930s, 1940s, and 1950s – when latent-learning experiments with animals (e.g., Tolman & Honzik, 1930) and motor-learning experiments with humans (e.g., Adams & Reynolds, 1954) demonstrated that considerable learning could happen across a period when there were few or no changes in performance. More recent findings have demonstrated that the converse is true as well – that is, it is also the case that little or no learning can happen across periods when there are substantial changes in performance (for reviews, see Bjork, 1994, 1999; Christina & Bjork, 1991; Schmidt & Bjork, 1992).

Thus, a major problem confronting any designer of treatment or instruction is that performance *during* treatment or instruction does not provide a reliable index of whether the goals of treatment or instruction have been achieved. Conditions of treatment or instruction that enhance performance, or accelerate the rate of desirable changes in behaviour, can fail to support long-term retention and transfer. Conversely, conditions that introduce difficulties for students, trainees, or patients – slowing their apparent rate of progress – may prove optimal, as measured by the long-term consequences of instruction or treatment.

Our goal in the present chapter is to examine the optimization problem from the standpoint of a theoretical framework we have come to call a "new theory of disuse" (Bjork & Bjork, 1992). The theory distinguishes between *storage strength*, a measure of learning, and *retrieval strength*, a measure of current ease of access – a distinction that is consistent with the time-honoured distinction between *learning* and *performance*. From the standpoint of the theory, programmes of treatment and instruction are frequently far from optimal for two reasons: (1) retrieval strength is confused with learning; and (2) manipulations that – according to the theory – optimize the gain of retrieval strength are *not* those that will optimize the gain of storage strength that is necessary to support long-term retention and transfer, or in the case of treatment, to maintain the newly learned desired behaviour and to prevent the return of the old, undesirable behaviour. In the present chapter, we focus on implications of the theory for optimizing treatment, especially of fears and phobias; for a discussion of the implications of the theory for the optimization of instruction and training, see Bjork (1999).

Before moving on to the assumptions of the new theory of disuse in greater detail, we need to characterize treatment, and the problem of changing behaviours, as a learning problem. In the following characterization we lean heavily on the work of Mark Bouton and his collaborators (e. g., Bouton, 1994, 2000; Bouton & Swartzentruber 1991), who have provided an insightful analysis of clinical treatment – and the maintenance or lapse of behavioural changes – from a learning-theory perspective. We also lean heavily on the work of Michelle Craske and her collaborators (Lang & Craske, 2000; Lang, Craske, & Bjork, 1999; Mystkowski, Craske, & Echiverri, 2002; Rodriguez, Craske, Mineka, & Hladek, 1999; Rowe & Craske, 1998a, 1998b; Tsao & Craske, 2001), who have provided innovative and systematic research on the exposure treatment of fears and phobias from a therapy-as-learning perspective.

Behavioural change as new learning

At the risk of oversimplification, the challenge confronting a therapist – from a learning-theory perspective – is to structure the conditions of treatment so as to enable a patient to replace earlier-learned non-adaptive behaviours with newly-learned more-adaptive behaviours. Someone suffering a debilitating fear of spiders, heights, or public speaking, for example, has learned – prior to entering treatment and perhaps over a long period of time – a pattern of emotional and behavioural responding to certain situational cues that interferes with and constrains his or her daily life. The problem for the therapist (and the patient) is to replace that pattern of responding with a more adaptive pattern of responding. From a learning-theory standpoint, the problem is one of *counterconditioning*.

Evidence abounds, however, from both human and animal research, that new learning does not replace or overwrite old learning. Extinction or counterconditioning procedures that might seem to have eliminated a particular response to a particular stimulus configuration, or replaced that response with another response, do not actually replace the original stimulus–response association. By some measures, in fact, such procedures leave the original stimulus–response association at full strength (see, e.g., Rescorla, 1993, 1996, 2001). Some of the types of evidence from the animal-learning literature for that assertion (as summarized by Bouton, 1994) are *renewal, reinstatement*, and *spontaneous recovery*, phenomena that we describe in the next section.

Recovery effects in extinction and counterconditioning

Renewal The phenomenon of *renewal* refers to the recovery of the original stimulus–response association when an animal is brought back to the original conditioning context after undergoing extinction in a different context. Bouton (1993), for example, has shown that when conditioning (e.g., tone–footshock) occurs in one context (say, A) and then extinction (e.g., tone presentation alone) occurs in another context (say, B), presentation of the tone alone back in context A will result in a full recovery of the original conditioned fear response to it. Furthermore, renewal can also occur when the tone is presented alone in a third context (say, C); that is, a context in which neither the original conditioning nor the extinction took place. In contrast, however, extinction performance seems to depend on testing in the context in which extinction occurred. In other words, whereas the original conditioned fear response generalizes to new contexts, the learned extinction response does not (e.g., Bouton & Bolles, 1979; Bouton & Brooks, 1993).

Reinstatement The phenomenon of *reinstatement* refers to the reappearance or reinstatement of an extinguished stimulus–response association following presentation alone of the original unconditioned stimulus (e.g., Rescorla & Heth, 1975). If, for example, following the extinction of a conditioned fear response to a tone, the unconditioned stimulus of footshock is presented by itself, the fear response will return when the tone is presented again in that same context (e.g., Bouton, 1984; Bouton & King, 1983). As interpreted by Bouton and colleagues, the presentation of the unconditioned stimulus alone creates an association between it and the contextual cues present at the time. Those contextual cues then give rise to the expectation of the unconditioned stimulus, resulting in a return of the extinguished response when the tone alone is presented.

Spontaneous recovery The phenomenon of *spontaneous recovery* refers to the return of a previously extinguished response to a conditioned stimulus with the passage of time since extinction. If, as suggested by Bouton (2000) and, previously, by Estes (1955), the passage of time is assumed to allow a new contextual background to emerge, then spontaneous recovery can be thought of as a renewal effect that occurs when the previously extinguished stimulus is encountered in a new temporal context.

Of considerable relevance for treatment, all three of these recovery effects have also been shown to occur after counter-conditioning. Peck and Bouton (1990), for example, have demonstrated a dramatic renewal effect when tone–shock pairings (or tone–shock conditioning) occur in context A, then tone–food pairings (or tone–food conditioning) occur in context B, and then the tone is presented back in context A. Even when fear responding to the tone has completely disappeared and been replaced by food responding by the end of the second conditioning phase, when back in context A, fear responding returns in response to the tone. (It should be noted that this effect does not depend on the tone–shock pairings occurring first; that is, renewal of the first learned response also occurs when tone–food pairings are followed by tone–shock pairings.)

Additionally, Brooks, Hale, Nelson and Bouton (1995) have shown that reinstatement occurs following a few presentations of shock alone after the originally learned fear responding to tone–shock pairings has been replaced by food responding to tone–food pairings. As with extinction, however, the shock-alone presentations have to be presented in the testing context, causing the expectancy of shock in that context and, thus, a return of the fear response to the tone. And, finally, spontaneous recovery of the first conditioned response has also been shown to occur simply with the passage of time. If tone–shock conditioning is followed by tone–food counterconditioning, for example, the behaviour that is most likely to occur in response to the tone sounded alone depends on when the tone is subsequently presented. After a short delay, such as one day, the behaviour that dominates tends to be the recently learned (food-appropriate) behaviour, whereas after a long delay, such as a month, the first-learned (shock-appropriate) behaviour becomes dominant (Bouton & Peck, 1992).

Thus, to the extent that behavioural changes acquired during the treatment of fears and phobias constitute learning new responses to the same cues with which undesirable responses are associated, such as a debilitating fearful response to spiders, then someone undergoing treatment is vulnerable to all of the recovery effects described above – that is, renewal, reinstatement, and spontaneous recovery. The fact that the old fearful responding is not replaced or overwritten by the new non-fearful responding means that both associations remain in memory and compete for retrieval – with, unfortunately, the odds often stacked in favour of fearful responding, given the dynamics of renewal, reinstatement, and recovery and the longer period over which the fearful responding was acquired.

In the next sections, we turn to a description of the new theory of disuse, a framework that we have proposed to explain several distinctive qualities of human memory, which is also quite compatible with the just described perspective of new learning in conditioning and counterconditioning terms, advanced by Bouton and his colleagues (e.g., Bouton, 1994, 2000; Bouton & Swartzentruber, 1991). We first describe the new theory of disuse and its assumptions. We then indicate how these assumptions are compatible with the characterization of treatment and the problem of changing behaviours as a problem of new learning and how its assumptions can thus point the way to improved conditions of treatment; that is, conditions that can enhance its long-term effectiveness. We then describe studies involving exposure therapy that were designed to test some implications of the new theory of disuse respecting how treatment conditions should be structured to enhance the effectiveness of therapy.

COMPETITIVE DYNAMICS IN LEARNING AND MEMORY: A NEW THEORY OF DISUSE

The new theory of disuse (Bjork & Bjork, 1992) was formulated to provide an account of certain fundamental phenomena that characterize human learning and memory. The assumptions of the theory were influenced heavily by certain "important peculiarities" of human memory. Among these peculiarities are the following: (1) a remarkable capacity for storing information coupled with a highly fallible retrieval process; (2) what can be accessed from memory at any one time is heavily dependent on the current environmental, interpersonal, emotional, and body-state cues; (3) the act of retrieving information from memory is a dynamic process that alters the subsequent state of the system; and (4) access to competing memory representations regresses over time – that is, with the passage of time and accompanying intervening events, memory representations learned earlier become more accessible and competing memory representations learned more recently become less accessible (for a discussion of such regression effects, see Bjork, 2001).

Such important peculiarities are both important and strange because they describe characteristics of human memory that differ markedly from the characteristics of man-made memory devices, such as a videotape recorder or the memory in a computer. In that sense, they provide a kind of guide to the functional architecture of human learning and memory and, especially, how that architecture differs from the architecture that characterizes man-made recording devices of various kinds.

The new theory of disuse versus Thorndike's (1914) "law of disuse"

A kind of conceptual starting point for the new theory of disuse derives from a real-world observation – namely, that no matter how well learned items are at some point in time they eventually become non-recallable given a long enough period of disuse. Thus, a home phone number, or street address, or friend's name, which may have been effortlessly recallable at one point in time, will nonetheless become non-recallable given a long enough period of disuse. As measured by other indices, however, such as recognition and, especially, relearning, it is possible to demonstrate that such information still resides in your memory and at essentially full strength. That is, what is lost to us with disuse is not the memories per se, but access to those memories.

In Thorndike's (1914) original "law of disuse," disuse was assumed to lead to decay of the actual memory representations. In the *new* theory of disuse, memory representations, once encoded in long-term memory, are assumed to remain in memory, but – without intermittent access to those representations – they eventually become non-retrievable.

In short, the momentary ease of access to a memory representation, which may be a product of recency or prevailing contextual and other cues, needs to be distinguished from the more permanent/learned representation of that information in memory. In the new theory of disuse, this distinction is captured by assuming that items in memory are represented by two types of strengths: (1) *retrieval strength*, which refers to momentary ease of access; and (2) *storage strength*, which refers to how "entrenched" or interassociated a given item is with other items in memory – that is, how well learned that item is.

Such a distinction is not new. In fact, learning theorists dating back to the heydays of learning theories in the 1930s, 1940s, and 1950s, all found it necessary to make such a distinction in order to account for a variety of phenomena, all of which pointed to the necessity to distinguish between *performance* and *learning*. Hull (1943), for example, distinguished between "momentary reaction potential" and "habit strength", and Estes (1955) distinguished between "response strength" and "habit strength". What is new are the assumptions of the new theory of disuse as to how retrieval strength and storage strength interact and change as a function of study and retrieval events.

Assumptions of the new theory of disuse

The following assumptions attempt to capture the dynamic interplay between the storage and retrieval strengths of a memory representation.

Assumption 1 An item or representation in memory is indexed by two strengths: (1) *storage strength*, which represents how well learned, or inter-associated, that representation is with other representations in memory; and (2) *retrieval strength*, which reflects how accessible, primed, or activated, that representation is with respect to the cue or cues guiding retrieval. The probability that an item can be recalled is completely determined by its retrieval strength (and on the retrieval strength of other items associated with the same cue as described in Assumption 3, below) and is independent of its storage strength.

That is, storage strength is a latent variable that has no direct effect on performance. Items with high storage strength can have low retrieval strength (e.g., a phone number you previously had for 5 years but not for the last 20 years), and items with low storage strength can have high retrieval strength (e.g., your hotel room number on the third day of your stay at a resort hotel on a summer vacation).

Assumption 2 The storage strength of an item is assumed to grow as a pure accumulation process in response to opportunities to study or recall that item; that is, it is assumed that storage strength, once accumulated, is never lost. Consequently, there is essentially no limit on the amount of information that can be stored in long-term memory; that is, on the sum of storage strengths across items. Storage strength for a given item, however, is assumed to grow in a negatively accelerated fashion; that is, the increment in its storage strength owing to a study or test event is a decreasing function of its current storage strength. Furthermore, increments in storage strength are also assumed to be a decreasing function of an item's current retrieval strength; that is, high retrieval strength is assumed to retard the accumulation of additional storage strength. Or, stated differently, the more accessible or activated an item's representation in memory is at the time of a study or test event, the less its storage strength can be increased as a result of those events.

Assumption 3 Whereas storage capacity is assumed to be unlimited, retrieval capacity is not; that is, there is a limit on the total number of items that are retrievable at any one point in time in response to a retrieval cue or configuration of cues. Two limits on retrieval capacity are assumed. First, because retrieval strength – in contrast to storage strength – is lost as a function of subsequent study and test events on other items, there is an overall limit on retrieval strength. At some point, a kind of dynamic equilibrium is reached where any gain in retrieval strength for items being studied or tested is offset by a corresponding loss in retrieval strength summed across other items in memory. Second, owing to the cue-dependent nature of retrieval assumed in the model, for a given item to be recalled in response to a given cue, (a) its representation must be discriminated from other representations in memory associated to that same cue, and (b) it must be reconstructed or integrated from its representation. Discriminating a given item is assumed to be a function of its retrieval strength relative to the strength of other items in the cued set. Reconstructing the item for output is assumed to be a straightforward function of its absolute retrieval strength.

Together, these two limits on retrieval strength imply that as items are added to memory, or as the relative strengths of certain items are increased, other items become less recallable.

Assumption 4 Both the act of retrieving an item from memory and the act of studying that item result in increments to its retrieval strength and storage strength, but retrieval is the more potent event. That is, the act of successfully retrieving an item results in larger increments to its storage and retrieval strengths than does the act of studying it again. In either case, however, increments in an item's retrieval strength are assumed to be a decreasing function of its current retrieval strength and an increasing function of its current storage strength. Consequently, the benefits of a successful retrieval, in terms of its influence on that item's subsequent retrievability, are larger the more difficult or involved the act of retrieval (low retrieval strength) and the better registered the item is in memory (high storage strength).

Assumption 5 Decrements in an item's retrieval strength, owing to the learning or retrieval of other items, are assumed to be greater the higher the item's current retrieval strength and the lower the item's current storage strength. Importantly, then, storage strength acts to enhance the gain and to retard the loss of retrieval strength.

On the basis of the foregoing assumptions, it follows that increasing the retrieval strengths of certain items through study or test events makes other items less retrievable. Furthermore, according to the theory, this competition for retrieval strength takes place at the level of retrieval cues, which are assumed to consist of current environmental, interpersonal, emotional, and body-state stimuli, real or imagined, that have been associated with a given item in the past.

Of particular relevance to issues of treatment, then, the theory states that when a cue is reinstated, either physically or imaginally, competition for retrieval among the representations in memory associated with that cue (or context) takes place, and whether a given memory representation is retrieved (or is the representation that determines the behavioural response produced in response to that cue) depends, not only on the absolute strength of its association to that cue, but also on the strengths of the associations of other memory representations to that cue. That is, in the presence of a given cue or context, whether a given memory representation will determine the behavioural response that occurs, depends on its relative as well as absolute retrieval strength with respect to those cues or context.

Also of particular relevance to issues of treatment and therapy is the theory's assumption that storage strength, once accumulated, is never lost. Thus, the retrieval strength of a given response can be decreased and eventually lost with disuse, but the learned representation of a response and its association to relevant cues remains in memory.

In general, as we have argued elsewhere (Bjork, 1989; Bjork & Bjork, 1988; Bjork & Bjork, 1992), the fact that retrieval strength, but not storage strength, is lost plays an adaptive role in the everyday use of our memories. Because old, out of date, information becomes non-retrievable, owing to the learning and use of new information, it does not interfere in the recall of the new information. The old information, however, remains in memory, meaning that it remains familiar and identifiable when it reoccurs, and – should circumstances change making the old information relevant again – it can be relearned rapidly, becoming readily accessible again, with significant savings compared to its original learning. In the case of therapy, however, the goal is to replace an old way of responding with a new way of responding. From that standpoint, it is a major problem that old associations and ways of responding remain in memory and are susceptible to relearning and recovery.

THE NEW THEORY OF DISUSE AS A GUIDE TO OPTIMIZING TREATMENT

With respect to the interplay of new associations and competing old associations, one broad implication of the new theory of disuse is that treatment conditions should be structured to optimize the storage strength of new, non-fearful, responding, rather than the retrieval strength of such responding. This implication is especially important because a therapist can easily be fooled by the current retrieval strength of non-fearful responding. That is, to the degree that those responsible for treatment interpret current performance – retrieval strength – as learning, they can not only be fooled as to the success of treatment, they can also be influenced to structure the conditions of treatment in far from optimal ways, as we describe below.

Spacing of practice, retention intervals, and their interaction

The effects of spacing or distributed practice on learning are complex. The ideal spacing interval (i.e., the temporal spacing of practice, learning episodes, study attempts, or training trials) has been shown (e.g., Glenberg & Lehmann, 1980) to be a function of the length of the final retention interval – that is, of the interval between the last presentation of the to-be-learned material and the testing of it and, thus, the interval over which it must be maintained. More specifically, when the retention interval is short, closely spaced study or learning episodes (i.e., *massed* practice, such as cramming all night before a morning exam) tend to produce somewhat better test performance than do study or learning episodes that are spaced further apart (i.e., *distributed* practice). When, however, the retention interval is long, distributed practice produces significantly better retention – often performance that is more than twice as good as that produced by massed practice. This latter effect – that distributed or spaced practice enhances long-term retention and performance, often referred to as the *spacing effect* – is one of the more robust and general findings in learning research. It holds for multiple time scales, types of to-be-learned material, and types of learners (see, e.g., Baddeley & Longman, 1978; Bahrick, Bahrick, Bahrick, & Bahrick, 1993; Lee & Genovese, 1988; for reviews see Dempster, 1996; Glenberg, 1992).

To the degree that the effects of treatment trials are subject to the same interaction of spacing interval and retention interval, which seems a safe assumption given the generality of such effects, therapists are clearly at risk of choosing massed practice over spaced practice. That is, if current performance is assumed to reflect treatment success, then the schedule of trials that will appear optimal is massing of practice, because it will result in more rapid apparent progress.

The new theory of disuse provides a quite natural account of the observed interaction of spacing interval and retention interval. According to the theory, the advantage of massed practice at short retention intervals arises because massed study episodes lead to a more rapid growth in retrieval strength than do spaced study episodes, owing to the greater loss of retrieval strength between successive spaced trials, versus between successive massed trials. When retention is tested at a short interval, retrieval strength – which determines momentary performance – will be higher in the case of massed than distributed practice. On the other hand, distributed practice produces greater increases in storage strength than does massed practice because, as outlined in Assumption 2, above, increments in storage strength are a negatively accelerated function of current retrieval strength. With distributed practice, there is more forgetting or loss of retrieval strength between the repeated study or learning episodes, which creates better conditions for new learning – that is, greater increments in storage strength. In turn, the greater accumulation of storage strength with distributed practice slows the loss of retrieval strength with disuse (i.e., across the retention interval), resulting in better performance after a delay, such as a delay from the end of treatment to a real-world context in which non-fearful responding is desired.

It is important to emphasize that a therapist is not the only one susceptible to being fooled by retrieval strength. Patients, too, can interpret rapid progress as success and be unaware that a rapid reduction in fearful responding during treatment, or rapid progress in, say, a behavioural approach test in the case of spider phobia, does not ensure success at a delay and outside of the treatment context. In fact, according to the new theory of disuse, rapid progress may constitute a kind of warning sign – that retrieval strength is being accumulated at the expense of storage strength.

In the context of instruction, Bjork (1994) has referred to conditions such as spaced practice as *desirable difficulties*. Other such difficulties include interleaving, rather than blocking, practice on separate tasks; varying, rather than keeping constant, the conditions of practice; reducing, rather than increasing feedback to the learner; and using tests, rather than study trials, as learning events. They are all "difficulties" because they introduce challenges for the learner and typically slow the apparent rate of acquisition. They are "desirable" because they then, typically, enhance long-term retention and transfer.

Retrieval as a learning event

When treatment sessions are spaced, retrievals of new non-fearful responses in the next training session will be more difficult, owing to the decrease in retrieval strength between sessions, but such retrievals – provided they are successful – will (owing to Assumption 4 above) be powerful learning events, far more powerful than when the act of retrieving is easy. That is, when retrieval strength is high (as it would be in massed practice) versus when low (as it would be in spaced practice), the act of retrieval is easier, but also less effective from the standpoint of increments in storage strength.

It is important to emphasize, however, that for a retrieval attempt to lead to a large gain in storage strength it not only needs to be difficult, but also successful. The challenge, therefore, is to structure the timing of sessions such that there is a drop off in the retrieval strength of the non-fearful behaviour between sessions, but not so great a drop off that the retrieval attempt in the next session is not successful. If retrieval of the non-fearful response is not successful, and, if instead, the old fearful response is retrieved, then the beginning of a relapse may be set in motion. Such an outcome is likely because, while the retrieval strength of the old fear response will be lowered owing to the intervening treatment sessions, its storage strength will remain high, built up by years of the patient responding fearfully to the fear-evoking stimulus on a variety of occasions and in a variety of contexts. Thus, a single retrieval of it could return its retrieval strength to its nearly full pretreatment level; thus, beginning a relapse to the old way of responding.

A potentially promising way to optimize the scheduling of treatment sessions across an intervention is to use what has come to be called *expanding retrieval practice* (Landauer & Bjork, 1978). In this method of scheduling practice, the first retrieval attempt is scheduled shortly after the first study or learning episode, the next retrieval attempt is scheduled after a slightly longer retention interval, the third after a still longer interval, and so forth. Ideally, each retrieval attempt should occur at the point when retrieval would be maximally difficult, but still possible, given the present level of retrieval strength. Each successive retrieval attempt would then act as a potent learning event, producing increases to storage strength as well as retrieval strength and, thereby, enabling the next retrieval attempt to be successful at a still longer interval.

Expanding retrieval practice has been shown to have an advantage compared to both massed and evenly spaced retrieval practice for the learning of verbal material as well as motor skills (for reviews see Bjork, 1988; Cull, Shaughnessy, & Zechmeister, 1996; Schmidt & Bjork, 1992) and for patients with memory disorders (Schacter, Rich, & Stampp, 1985). Again, however, in the context of fear-reduction therapy, it would be of critical importance to manage the spacing of training sessions such that the likelihood of successfully retrieving the new non-fearful behavioural response is kept high, while the likelihood of retrieving the old fearful behaviour response is kept low to avoid its being accidentally evoked in the training context.

Variation as a desirable difficulty

Introducing variation into the learning of a new task has been demonstrated to benefit both the long-term retention of the learning and its generalizability (e.g., Shea & Morgan, 1979; Simon & Bjork, 2001; Smith, Glenberg, & Bjork, 1978; Smith & Rothkopf, 1984; for a discussion of such findings, see Schmidt & Bjork, 1992). These benefits of variation are thought to occur for a number of reasons. First, in terms of the new theory of disuse, retrieval is made more difficult via the variation because the cues available from the just prior learning episode will be at least somewhat changed from those of the current learning episode, thus producing greater increments to storage strength as well as retrieval strength (for reasons why conditions that create forgetting can also enable learning, see Bjork, 1999; Cuddy & Jacoby, 1982; Estes, 1955; Jacoby, 1978). Second, each time the new learning occurs in a slightly different context, it becomes associated with different retrieval cues and, thus, it becomes retrievable in response to a greater variety of cues and contexts, improving the generalizability of the newly learned response or task. Third, variation in the task or tasks to be learned is assumed to force the learner to engage in certain types of higher-order learning in order to overcome the interference among the tasks – for example, to discover similarities and differences among the tasks to be learned, or to develop a common strategy that enables performance of the basic task despite variations in it (e.g., Battig, 1972).

In the case of fear-reduction therapy, variation in the task to be learned (i.e., responding in a non-fearful manner to the previous fear-evoking stimulus) could be accomplished by varying the nature of the feared stimulus (say, exposing the learner to different types of spiders or snakes) or by varying the treatment context (say, having the learner encounter the spider or snake in different physical or environmental settings and when experiencing different types of internal states). Introducing these types of variation into the treatment tasks or learning episodes should result in the build up of both the storage and retrieval strength of the new non-fearful response to a variety of cues, both external and internal, and thus increase the likelihood that there will be at least some retrieval cues for the new learning present in situations likely to be encountered by the learner after treatment. The practice of having the learner retrieve the non-fearful behaviour when in different internal states would have the benefit of building up the retrieval strength of the new behaviour to such cues – such as elevated heart rate or increased respiration. Thus, such internal states can become retrieval cues for the new non-fearful behavioural response, not just the old fearful behavioural response.

Overlearning and repeated learning

As we have previously pointed out (Bjork & Bjork, 1992), a long-established result in the study of learning is that additional trials given after an animal or human participant has achieved perfect performance (overlearning), or additional relearning sessions to bring performance back to the original criterion level (repeated learning) both serve to slow the rate of subsequent forgetting (e.g., Ebbinghaus, 1885/1964; Krueger, 1929). In the new theory of disuse, the assumed distinction between storage and retrieval strengths readily accounts for these two effects. Performance is a function of momentary retrieval strength, and performance cannot go beyond 100% correct. Storage strength, however, can continue to accumulate in response to overlearning or repeated learning, and increased storage strength acts to slow the loss of retrieval strength, which would be revealed in the observed slower rate of forgetting following overlearning or repeated learning.

In the context of fear-reduction therapy, overlearning results would imply that continuing fear-reducing sessions beyond the point where the patient or learner reports little or no fear in the presence of the previously fear-evoking stimulus might have the benefit of slowing the forgetting of the newly learned behaviour once treatment is stopped. Furthermore, repeated learning or refresher treatments could be used to help return the retrieval strength of the new non-fearful response to the level it had attained at the end of treatment. Additionally, because the retrieval strength of the new behaviour would typically be lower at the time of relearning than it was at the end of treatment, these relearning trials would be highly beneficial as far as increasing the storage strength of the new behaviour, not just its retrieval strength. It would be critical, however, as was discussed with respect to devising an optimal spacing interval for treatment sessions across the original period of intervention, to administer any relearning trials for the new non-fearful response before its retrieval strength has been so diminished with disuse as to make it non-retrievable.

When thinking about how to optimally structure the spacing of relearning trials in the context of fear reduction, some work by Bjork and Fritz (1994) in the context of the new theory of disuse – suggesting that massing trials in a relearning treatment phase might be as effective as distributing them – seems of great relevance. Working with a quantitative version of the theory, Bjork and Fritz showed that the theory predicted that massed relearning not only produced more rapid reacquisition during training than does spaced relearning, but also that this advantage was maintained over a much longer retention interval than is the case for initial learning.

This prediction, though initially very surprising, is quite understandable. Because storage strength, once accumulated, is assumed to be permanent, the storage strength that results from original learning carries over to relearning. The disadvantage that massed practice would typically have during training – a limited accumulation of storage strength – is, therefore, mitigated. As pointed out by Lang, Craske, and Bjork (1999), this prediction of the new theory of disuse has both positive and negative clinical implications. On the one hand, it suggests that providing a client or patient with a single massed relearning treatment session could be just as effective as several, spaced relearning treatment sessions. On the other hand, however, it implies that a single massed fear-inducing episode in which the old fearful response is evoked could not only restore fearful responding to its pretreatment retrieval strength, but also increase its storage strength, undoing many of the gains made during treatment. But again, as retrieval strength decreases over time with disuse, well-timed relearning treatment trials could be the best way both to maintain the retrieval strength of the newly learned non-fearful behaviour and to prevent an inadvertent relapse to the old fearful behaviour.

In the next section, we describe and discuss examples of exposure-therapy experiments carried out by Craske and her collaborators, experiments that were designed to test a broad implication of the new theory of disuse – namely, that treatment conditions should be structured to optimize the storage strength, not simply the retrieval strength, of non-fearful responding.

OPTIMIZING STORAGE STRENGTH IN THE TREATMENT OF FEARS

Applying the new theory of disuse to exposure-based treatment of fears, the new to-be-learned or to-be-remembered information is a new association between a previous fear-evoking stimulus (e.g., a snake or spider, a closed space, public speaking, etc.) and a new non-fearful response. Because storage strength is not lost, however, the newly acquired association or memory representation does not replace the old fearful association or memory representation; rather, both representations will be stored in memory and compete for retrieval. In a post-treatment encounter with the previously feared stimulus, the representation that will determine how the patient responds – with fearful or non-fearful feelings and behaviour – will depend on the relative retrieval strengths of the two associations to the available retrieval cues. Thus, a goal of treatment is not only to associate a new non-fearful response to the previously feared stimulus, but also to increase its retrievability; that is, the likelihood that it will be the response retrieved rather than the old fearful response. In the studies described next, Craske and collaborators examined different procedures – suggested by the new theory of disuse – in an attempt to maximize both the storage and the retrieval strength of new, non-fearful, associations.

Exposure therapy and the effects of spacing

According to the new theory of disuse, massing exposure trials during treatment should result in a more rapid reduction in the retrieval strength of old, fearful, responses and a rapid build up of retrieval strength for new, non-fearful, responses, but a limited build up of the storage strength of the non-fearful responses. Distributed spacing of exposure trials, on the other hand, in particular the use of an expanding schedule of retrieval practice, should lead to a greater increase in the storage strength of the new, non-fearful, response and, thus also, to its slower loss of retrieval strength following the end of treatment. In other words, whereas massed exposure trials may produce faster apparent learning of the new non-fearful response than do spaced exposure trials, the potential for return of fear to occur (that is, the reinstatement of the old fearful way of responding) should be greater in the former than in the latter case. Additionally, because the spacing of exposure trials (or retrieval opportunities) allows for a greater change in temporal context cues across exposure trials, the new non-fearful response should build up retrieval strength to more different types of cues across the duration of the intervention when exposure trials are spaced versus massed, leading to a greater generalizability of the newly learned response when acquired under distributed versus massed conditions. To assess the validity of these predictions, Rowe and Craske (1998a) compared the relative benefits of a massed versus an expanding-spaced exposure schedule for treating fear of spiders.

In their study, participants reporting a fear of spiders were randomly assigned to receive massed exposure trials or expanding-spaced exposure trials, and the two groups were compared on a number of measures on three different occasions: pre-training, post-training, and at a one-month follow-up. Participants in the massed-exposure condition received four exposure trials that were conducted consecutively on the same day as the pre-and post-assessments. Participants in the expanding-exposure condition received exposure trials on four different occasions that were spaced in a 1–2–4–8 pattern; that is, with the time between successive exposure trials expanding from only one day, to two days, to four days, and then eight days.

The assessment measures included several behavioural assessment tests (BATs), such as patients being required to approach the glass cage containing the training (or control) spider (a tarantula with an abdomen of approximately 7.5 cm [3 inches] in length), and touching the tarantula with either a pencil or a Q-Tip. In addition, heart rate was recorded and several self-report measures, designed to reveal the strength of certain fear-related feelings, such as the participant's maximum level of anxiety during the task, perceived degree of danger during the task, and perceived chances of being bitten, were collected. In the post-training and follow-up assessments, participants were exposed to the original control spider to assess fear reduction. Additionally, to assess generalization effects, participants were also exposed to a novel spider that differed in size, colour, hairiness, and speed of movement to the control spider.

Consistent with the predictions of the new theory of disuse, although both groups exhibited fear reduction or habituation across exposure trials, participants in the expanding-exposure condition exhibited less habituation than did the participants in the massed-exposure condition. Across trials, all measures of fear revealed a linear decline for the massed-exposure group; whereas the same means revealed a more erratic course of fear reduction or habituation for the expanding-exposure group, consistent with the assumption that spaced exposure trials would increase the difficulty of retrieval of the non-fearful response and, thus, slow down the course of habituation. Indeed, the heart rate of the expanding-exposure participants continued to increase across exposure trials, consistent with the notion that retrieval of the non-fearful response is more difficult given an expanding, versus a massed, schedule of exposure trials. Additionally, on the immediate post-training assessment tests with the control spider, the expanding-exposure participants responded more poorly in terms of maximum reported fear, danger ratings, and heart rate compared to the massed-exposure participants.

Thus, as in many previous studies demonstrating more rapid improvement in performance with massed practice versus spaced practice during instruction or training, it appeared that a massed scheduling of exposure trials was superior to a spaced scheduling of exposure trials for the reduction of fear. But Rowe and Craske's inclusion of a generalization test at the immediate post-treatment assessment revealed this apparent superiority of massed exposure trials to be misleading. Consistent with the new theory of disuse, when exposed to the novel spider, massed-exposure participants evidenced significant return of fear both on the post-assessment BAT and in terms of their self-reported maximum fear and danger ratings. In contrast, the expanding-exposure participants did not show increases in these measures.

Finally, of critical importance is the question of how participants in the two groups performed at the one-month follow-up assessment. In terms of the new theory of disuse, it should be the case that participants in the expanding-exposure condition – despite having shown less habituation during treatment and poorer performance on the immediate post-treatment assessment with the control spider than did the massed-exposure participants – should nonetheless show superior maintenance of fear reduction. As reported by Rowe and Craske (1998a), this prediction was "strikingly demonstrated" in the self-reported measures of maximum fear, which showed a significant increase for the massed-exposure participants and a significant decrease for the expanded-exposure participants. Thus, although showing significantly better habituation across exposure trials as well as better performance on the immediate post-treatment assessment with the control spider, only the massed-exposure participants demonstrated a return of fear at the follow-up assessment. Furthermore, as they had done on the immediate post-treatment assessment, the massed-exposure participants also showed return of fear to the novel spider at the one-month follow-up assessment, whereas the expanding-exposure participants did not.

In summary, the pattern of results obtained by Rowe and Craske (1998a) strongly indicate that the structuring of exposure trials to maximize the growth of storage strength as opposed to the growth of retrieval strength, as is assumed to occur in spaced versus massed practice in the new theory of disuse, is one way to increase the long-term effectiveness of fear-reduction therapy – specifically, a decrease in the return of fear following treatment. It must be pointed out, however, that a study by Lang and Craske (2000) comparing massed-exposure training to expanded-exposure training in the treatment of fear of heights did not find a difference in return of fear between the two groups. Participants in this study, however, received nearly four hours of direct exposure and neither group showed a detectable return of fear between the end of treatment assessment and the one-month follow-up assessment. Possibly, with a longer delay, enhanced long-term retention of the non-fearful response for the expanded-exposure training would have emerged. In a similar study by Tsao and Craske (2001), which examined the effects of different spacing manipulations (massed, uniform, and expanding) on the reduction of fear of public speaking, participants in the massed-spacing condition showed the greatest return of fear at the one-month follow-up – in fact, their fear ratings at this time did not differ from their pre-treatment levels – whereas participants in both of the spaced conditions showed an impressive lack of return of fear at the one-month follow-up.

Based on these promising results, and as has been argued by Lang, Craske, and Bjork (1999), additional research in this area is clearly needed, both to extend it to clinically fearful populations and to determine the optimal spacing and follow-up intervals for the prevention of return of fear. According to the new theory of disuse, the optimal intervals would be those that allow some forgetting or decrease in the retrieval strength of the new non-fearful behaviour to occur between successive exposure trials, in order to make the retrieval of the newly learned response increasingly difficult (thus producing a larger increment to its storage strength), but not so difficult that successful retrieval during the next exposure trial is rendered impossible.

Exposure therapy and the effects of variation

As previously discussed, Bouton and colleagues (e.g., Bouton & Peck, 1992; Peck & Bouton, 1990; Brooks et al., 1995) have demonstrated that the recovery phenomena of renewal, reinstatement, and spontaneous recovery all occur following counterconditioning as well as extinction. Of particular relevance for fear therapy, Peck and Bouton (1990) have demonstrated renewal when tone–shock conditioning occurs first in context A, then tone–food conditioning in context B, and then the tone is encountered again back in the original context A. In other words, even though a new non-fearful response has been learned to the tone stimulus, when back in the context of the original learning of the fearful response to the tone, the fearful behaviour returns.

In addition, as demonstrated by Bouton and Swartzentruber (1991), even when placed in a new context C – that is, not the context of original learning – renewal of the old fearful response often occurs. Taken together these results suggest, as Bouton and colleagues have emphasized (e.g., Bouton & Nelson, 1994, 1998), that first learning generalizes, but second learning does not. That is, second learning appears to remain contextualized and highly dependent on the context in which it was acquired. In discussing these results with respect to the problem of relapse in behaviour therapy, Bouton and colleagues (Bouton, 1994, 2000; Bouton & Swartzentrauber, 1991) have argued that it is important to think of how to make the new learning generalize beyond the immediate context or the context present in therapy and, when so doing, to think of the context more broadly; that is, as including any background event or any changes in the features of the stimulus. An immediate implication of such an argument is that, during exposure therapy, contextual variation across exposure trials in either the background or the features of the stimulus should help to reduce return of fear.

In terms of the new theory of disuse, contextual variation during training would decrease the potential for return of fear in at least two ways. First, because retrieval is assumed to be cue dependent, increasing the storage and retrieval strength of the desired response to many retrieval cues will make it more likely to be the response retrieved in a future context. Second, contextual variation across exposure trials will make retrievals of the new response more difficult, thus adding to its storage strength and reducing its loss of retrieval strength across a retention interval or period of disuse. In short, according to the theory, retrieval strength of non-fearful responding should grow more rapidly without contextual variation, but long-term retention and generalizability of the to-be-remembered response should be greater with contextual variation.

To test these predictions, Rowe and Craske (1998b) compared the relative benefits of exposing participants to a constant stimulus versus multiple versions of a stimulus in the treatment of fear of spiders. As in the Rowe and Craske (1998a) study, participants reporting a fear of spiders were randomly assigned to receive either a constant-exposure treatment or a varied-exposure treatment, and the two groups were compared on a number of measures on three different occasions: pre-training, post-training, and at a three-week follow-up. Also, as before, the assessment measures included several behavioural assessment tests (BATs), heart rate, and several self-report measures designed to gauge the participant's level of anxiety.

A total of seven different tarantulas were used that varied in a number of ways, including shape, colour, hairiness, speed of movement and size. For each participant, one spider – referred to as the control spider – was presented at the pre-training, post-training, and follow-up assessments. Additionally, for each participant, a novel spider was presented at the post-training assessment, and a different novel spider at the follow-up assessment. During exposure trials, the varied-exposure participants were exposed to a different tarantula on each of four exposure trials; whereas, constant-exposure participants were exposed to only the control spider across their four exposure trials. Thus, including the spiders used for assessment (one control, and two novel), participants in the varied-exposure condition were exposed to a total of seven different spiders; whereas, participants in the constant-exposure condition were exposed to only three spiders. The seven tarantulas used were counterbalanced across the two exposure conditions so that each spider was represented an equal number of times in each of the seven possible presentations to ensure that no observed effects could be due to the particular characteristics of a given spider.

The study took place over two sessions: The first session, which included a pre-training assessment, four exposure trials, and two post-training assessment trials, lasted approximately two hours; and, the second, which occurred approximately three weeks after the first session, included two follow-up assessment trials and lasted for about half an hour.

Although not for all measures, the constant-exposure group, in general, exhibited significantly more habituation or fear reduction across the exposure trials and less reported anxiety during the immediate post-training assessment than did the varied-exposure group. With delay, however, the constant-exposure group showed a clear return of fear to the control spider, whereas the varied-exposure group did not. In terms of the new theory of disuse, the increase in retrieval difficulty, introduced by the changes in context (i.e., the characteristics of the spider) from one exposure trial to the next slowed down the reduction of fear in the varied-exposure participants during training. In the long-term, however, this increased retrieval difficulty across exposure trials, resulted in the accumulation of greater storage strength and thus a slower loss of retrieval strength across the retention interval, allowing the varied-exposure participants to retrieve the new non-fearful response when faced with the control spider after three weeks, whereas the constant-exposure participants could not.

At the three-week follow-up, however, both groups were found to exhibit return of fear when presented with the novel spider. Although disappointing, this result is consistent with the assumptions of both the new theory of disuse and the arguments of Bouton and colleagues as to the power of the context (or retrieval cues) to determine which of two competing memory representations will lead to observed behaviour. In the case of the new theory of disuse, the contextual cues present after three weeks and in the presence of a new spider are more likely to be ones for which the old fearful response has both greater storage strength and retrieval strength, built up across many years and in a variety of contexts, and thus is the response more likely to win in the competition for retrieval in the face of those cues. According to Bouton (1994), the return of fear to the new spider would be considered an example of renewal following counterconditioning.

As was the case with the earlier discussed study of Rowe and Craske (1998a), the present study also demonstrates the risk to both therapists and clients of being misled by performance during and immediately following training, which can often be a poor index of whether the type of learning that is the goal of training has actually occurred. On the basis of performance both during training and on the immediate post-training assessment task with the control spider, the constant-exposure procedure appeared to be the superior way of conducting fear-reduction therapy. Without the additional generalization test given immediately after training, or the delayed assessment with the control spider, the inadequacy of the constant-exposure procedure to that of the varied-exposure procedure would not have been revealed. Thus, the pattern of results observed by Rowe and Craske (1998a, 1998b) – like many others in the verbal-learning and motor-skills literature – emphasizes the need for both transfer tests and delayed retention tests to properly evaluate the efficacy of training procedures, as has been advocated by Schmidt and Bjork (1992). Additionally, they also demonstrate the risk of relying on the meta-cognitions of the learner or trainee to gauge the efficacy of the training procedure (see, Simon & Bjork, 2001, for a similar result with a motor-skills learning task). And, finally, they again underscore the risk to the therapist of being misled by the apparent ease of new learning or habituation during treatment into preferring what is actually a poorer method of treatment over a better method of treatment.

As with the optimal spacing of exposure trials within the period of treatment, how to vary context in order to minimize the return of fear following treatment needs additional research. One other study by Lang and Craske (1998), in which individuals who were afraid of heights were either exposed to varied stimuli and contexts (multiple heights in different locations) or to a single stimulus and context (one high location), has also shown that the varied exposure treatment leads to better performance or less return of fear at a one-month delay. Thus, contextual variation in exposure treatment seems a promising direction to take, but, as with the spacing of exposure trials, many questions remain to be investigated, such as how much variation is optimal and whether certain types of variation – such as varying the type of task versus only the features of the stimulus – might be more potent than others. And, finally, a promising line of research might be how best to combine these two manipulations – that is, the spacing of exposure trials and the variation of context across exposure trials. Perhaps there are combinations of these two manipulations that would have not just an additive effect on the learning of the new non-fearful response, but a superadditive or synergistic one, greatly enhancing the long-term effectiveness of such a treatment procedure.

CONCLUDING COMMENTS

We set out in this chapter to extend a theoretical framework, our new theory of disuse, which we developed in the context of research on verbal learning and skill acquisition, to the broad problem of changing behaviours, and, more specifically, to the treatment of fears and phobias. In drawing on, and trying to account for, the animal-learning research of Mark Bouton and his collaborators, and the exposure-therapy research of Michelle Craske and her colleagues, we are struck by the potential for cross-fertilization between research domains that, typically, have little to do with each other. We are struck as well, by the central role of memory – in learning, in treatment, and, as the title of this book states, in society. Finally, however promising the new theory of disuse may prove to be as a guide to optimizing treatment, one thing is clear: Research and theory are far better guides than are intuition and "common sense", both of which can lead us to choose poorer conditions of instruction over better conditions of instruction, and less-effective treatment over more-effective treatment.

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