**What more can we learn from early learning theory? The contemporary relevance for behaviour change interventions**

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Much of the current approach to behaviour change derives from early research in learning theory, i.e. the investigations and theories of classical conditioning and instrumental or operant conditioning. For example, more than 25 of the 93 behaviour change techniques (BCTs) in BCTTv1 (Michie, Richardson, Johnston et al., 2013)are directly related to learning theory. This is hardly surprising given that learning theory is about changing behaviour. To quote Landrine& Klonoff (2004, p. 545), “learning theory, the best theory of behavior and behavior change” or Skinner (1950), “Those who are interested in a science of behavior will insist that learning is a change in behaviour “.

Central goals of health psychology include the explanation of behaviour using theories of health behaviour change and the design of interventions to change behaviours such as smoking, attendance at screening, adherence to medication or delivery of evidence-based healthcare. These goals are quite similar to those of early learning theorists although the latter tend to express it slightly differently, for example Watson (1913) wrote that Psychology’s “theoretical goal is the prediction and control of behavior” while Skinner wrote: “If we have achieved true scientific understanding of man we should be able to prove this in the actual prediction and control of his behaviour” (Skinner 1972 p 259). “When we have achieved a practical control over the organism, theories of behavior lose their point…. When behaviour shows order and consistency, we are much less likely to be concerned with physiological or mentalistic causes.” (Skinner 1956 p 231). Skinner demonstrated unprecedented success in designing successful behaviour change interventions, for example in training two pigeons to play ping-pong (<https://www.youtube.com/watch?v=vGazyH6fQQ4>). Skinner described behaviour change as ABC, [A=antecedents, B=behaviour and C=consequences] with A->B->C. He proposed that behaviour was changed by altering antecedents and consequences and made considerable progress in establishing how A and C needed to change to achieve behaviour change.

Historically, learning theory became important as a basis for health-related interventions in the 1960s and 1970s. These interventions focussed on behaviour while still allowing that cognitive processes might have a causal role (Bandura, 1969). However, following success in dealing with anxiety disorders, the main intervention developments were in cognitive theory and methods. More recently, there has been increasing focus on behaviour as a cause of ill-health and, consequently, on behaviour change as an opportunity for prevention and intervention using methods developed from those used in clinical and social psychology. The aim of this paper is to re-visit learning theory to ascertain whether there is still more to be gained that might be useful in addressing current issues i.e. the things that may have been forgotten. It is suggested that we might regain some earlier explanatory insights but also refinement of some methods of intervention. In the following sections, each heading highlights a current issue followed by key learning theory constructs.

**Behaviour predicts behaviour:** *The Law of Exercise, Stimulus Control and the Premack Principle*

We regularly find that behaviour is predictable from previous behaviour and categorise this as past behaviour or habitual behaviour. This finding might be explained by causal factors such as thoughts or rewards persisting and therefore causing the behaviour on each occasion of repetition. Alternatively, habits are defined as learned responses and the building up of habit-strength by repetition in similar stimulus contexts (i.e. antecedents), resulting in ‘automaticity’ (Lally & Gardner, 2013), or “situation–behavior sequences that are or have become automatic, so that they occur without self instruction” (Triandis 1980, p. 204). However as early as 1898 Thorndike(1911 ) published the *Law of Exercise*, the observation that even an unrewarded behaviour would be repeated and become associated with a situation. The Law of Exercise states: “Any response to a situation will, other things being equal, be more strongly connected with the situation in proportion to the number of times it has been connected with that situation and to the average vigor and duration of the connections”. Thorndike observed that the spontaneous behaviour of cats in response to a new experimental situation tended to be repeated even though it prevented the rewarded behaviour, i.e. stimulus-response association rather than behaviour-reward association. Anecdotally, this accords with the experience of finding directions to a new destination – errors on the first occasion are frequently repeated on subsequent occasions. The resulting behaviours may be difficult to explain except as ‘usual behaviour’ and are challenging to change as no rewards are maintaining the behaviour and no conscious control is required to maintain it.

Additionally, behaviours on one occasion in a specific context may predict similar behaviour on subsequent occasions because the context acts as a ’discriminative stimulus’, i.e. a stimulus indicating that the target behaviour will be rewarded in this situation. Then the behaviour comes under *Stimulus Control.* Early experiments showed that rats learned to perform the rewarded behaviour if and only if the light signalling that rewards were available was lit. Similarly, academics are likely to find the grant application process rewarding only under the stimulus conditions indicating that funding is available.

While early learning theory such as Hull’s theory emphasised the role of physiological processes and the strengthening of stimulus-response connections to explain habitual behaviours, others recognised a role for cognitive processes, e.g. Tolman’s ‘cognitive maps’ (Tolman 1948). Subsequent explanations frequently refer to cognitive processes that might explain stimulus control. For example, Bandura’s social learning approach (1969, p 62-63) explained stimulus control in terms of both stimulus-response connections and cognitive processes characterised as ‘central mediational processes’. More recently, dual-process models such as Strack & Deutsch (2004) additionally offer an explanation of habitual behaviours that are not associated with rewarding consequences but are elicited by antecedent prompts or cues which function as stimulus control processes involving association with implicit cognitive or affective processes without the need for conscious or implicit motivation (Sheeran, Gollwitzer & Bargh, 2013).

Orbell and Verplanken (2010) demonstrated the importance of stimulus control in a predictive study of smoking in response to the cue of drinking alcohol in pubs and in an intervention study which increased the rate of dental flossing by cueing the behaviour to a stimulus situation using an implementation intention. The concept of stimulus control is currently used in weight management programmes, for example by reducing portion size so that the temptation to eat large quantities is reduced by removing the stimulus of having large amounts available and therefore reducing the need for inhibitory control (Poelman, de Vet, Velema, et al. 2015; Almiron-Roig, Tsiountsioura, Lewis et al., 2015 ). However, as Pagoto & Appelhans, (2015) point out, stimulus control may be particularly difficult to achieve in a home, work or leisure environment where one has to counteract the commercial use of stimulus control to generate an ever-present set of triggers to high food consumption and low energy expenditure.

Learning theory also makes predictions about when behaviour will *not* predict behaviour. Landrine & Klonoff (2004) have proposed an operant theory to explain the persistence or loss of health behaviours of immigrants as they adapt to a new culture. They propose that healthy behaviours, such as having a healthy diet or breast feeding, which have high prevalence and are under stimulus control in the previous culture ( e.g. they see other people performing these behaviours) are vulnerable and will decrease rapidly as immigrants adapt to the new culture of the USA where these behaviours are not so prevalent. They make specific predictions for different ethnic groups and about the extent to which previous health-sustaining or health-damaging behaviours predict behaviour in the stimulus context of the new culture and how these behaviours change as a result of acculturation. The theory is supported in population-level studies.

An entirely different way in which behaviour may predict behaviour is outlined in the *Premack principle*: i.e. high-probability behaviours (those performed frequently under conditions of free choice) can be used to reinforce low-probability behaviours. For example, rats were shown to learn lever pressing when rewarded by the opportunity to run in a wheel. The practice of using preferred behaviours as consequences to reward less preferred behaviours is commonly used with children e.g. ‘you only get to play if you finish your vegetables’. More importantly, such frequent regular behaviours have been useful in changing dysfunctional behaviours where no other reinforcers were feasible. These high-probability behaviours have reinforcing value for the individuals who perform them, but it is unclear whether they have intrinsically greater reward value which would generalise to other individuals. It is more common to identify behaviours for the specific individual as Amari, Grace& Fisher (1995) did in a single case study in which preferred foods were used to reward less preferred foods in order to achieve compliance with a ketogenic diet. A study by Horan & Johnson (1971) illustrates the use of the Premack principle in a self-management programme for weight reduction. Participants were required to think of both a positive and a negative consequence of losing weight before engaging in a high probability, habitual, but non-eating behaviour such as sitting on a chair. This intervention achieved greater weight reduction than a control condition in a randomised controlled trial. The effects achieved have been explained as due to response-deprivation during the period of the non-preferred behaviour. For example, access to Facebook may be used as a reward in a frequent user, but the effect may derive from restricted access while performing the target behaviour (see Domjan, 2014).

While current approaches to understanding and intervening to achieve behaviour change makes considerable use of the concept of habit, there might be gains in making more extensive use of stimulus control and the Premack principle.

**Removing a behaviour is more difficult than initiating a behaviour:** *Punishment, Negative Transfer, Differential Reinforcement of Other Behaviour (DRO) and Differential Reinforcement of Alternative Behaviour (DRA),* *Spontaneous Recovery.*

It is commonly found to be more difficult to achieve a desired behaviour change where the behaviour to be changed has become part of an established routine or habit rather than the introduction of a new, pattern of behaviour. Part of the problem is due to the methods used to remove undesirable behaviours. The problems of using *punishment* to remove a behaviour have been recognised at least since the early 1960s (Church, 1963). In addition to the ethical concerns and possible legal issues, the effects of punishment are unpredictable. While contingent punishment is likely to reduce the undesired behaviour, on occasions it may increase the behaviour and additionally there may be unanticipated side-effects including imitation or avoidance of the punisher, or increase in other potentially more undesirable behaviours. Punishment may also create an emotional response such as fear and there is ample evidence that fear arousal may not be effective in achieving the desired behaviour change unless applied in conjunction with efficacy enhancement as proposed by fear-arousal theories (Peters, Ruiter & Kok, 2013;Ruiter ,Kessels,Peters & Kok, 2014).

Simply training a different response in a critical context is likely to have problems of *negative transfer* i.e. the undesired behaviour associated with the context will persist. In studies of animal and human learning, training the association of a new behaviour to a stimulus context previously associated with a different behaviour is considerably more difficult than training a new behaviour to a new stimulus or even an old behaviour which was previously associated with one stimulus to a new stimulus (Postman, 1962).

A more effective, ethical, legal and feasible procedure is to reinforce other behaviours. In *differential reinforcement of other behaviour (DRO),* any period of absence of the target behaviour is rewarded, while in *differential reinforcement of alternative behaviour (DRA)* specific other behaviours are rewarded. Within the BCT taxonomy v1, DRO is BCT 14.7(reward incompatible behaviour) and DRA is 14.8(reward alternative behaviour). DRO is illustrated in a single case study in which a frequent health centre attender was reinforced for periods in which she did not seek a medical appointment (Johnston, 1987). When compared with other methods of removing behavioural responses, DRO is found to be quick and effective and to have lasting effects (Homer & Peterson, 1980). However, where it is appropriate to reinforce an alternative behaviour this is likely to be easier and more effective but one should bear in mind that any reinforcement of selected behaviours may inadvertently reduce or remove other desirable but unselected behaviours: a prime example is the doctors’ reduced rate of performing other clinical behaviours when a subset is financially rewarded (Maisey, Steel, Marsh et al., 2008).

The alternative behaviours reinforced in DRA should be chosen to be behaviours that compete with the target behaviour. The matching law proposes that the frequency of behaviours corresponds to frequency of reinforcement and therefore that more frequent reinforcement of alternatives will reduce the rate of the less desired behaviour (see Reed & Kaplan, 2011). In addition, the quality and delay in reinforcing it and the effort involved in the alternative behaviour will affect the success of DRA. However, control of competing reinforcers or reinforcers for competing behaviours may be outside the control of those wishing to achieve behaviour change, for example when commercial companies such as the food and alcohol industries market products which reinforce consumption behaviours with high frequency and involving low effort.

An additional problem in removing a behaviour lies in the persistence of the older behaviour in the behavioural repertoire, to cite Bandura (1969, p.413) “Contrary to the connotation of the term, extinguished behaviour is displaced rather than permanently lost.” The vanquished behaviours are readily ‘recovered’ when circumstances change, for example by reinstating reinforcement contingencies. In earlier animal studies, it was commonly observed that an apparently extinguished behaviour would occur occasionally and unpredictably, a phenomenon which was referred to as ‘*spontaneous recovery’*. An obvious example in a health context is when the ‘ex-smoker’ relapses (Conklin & Tiffany, (2002).

The problem of persistence of undesired behaviour is currently addressed in health psychology using models that owe more to cognitive psychology than learning theory. Several models explain or propose methods of overcoming unwanted but persistent behaviour patterns. Failures of executive control, especially of inhibitory control, have been suggested as explanations of lapses in behaviour i.e. behaviours not compatible with pursuing the individual’s goals and therefore showing failure of self-control. Recent evidence suggests that individuals with poorer executive control may gain from environmental changes that make cognitive control easier (Allan, Sniehotta & Johnston, 2013)and such changes are said to alter the ‘choice architecture’ or the environmental architecture influencing the behaviour (Hollands, Shemilt & Marteau, 2013). Developments of ‘coping planning’ and ‘implementation intentions’ are designed to reduce the impact of environmental stimuli in controlling or eliciting the undesired behaviours and aim to function by reducing cognitive load or enhancing self-control (Hagger 2015) at the point of behaviour. Nevertheless, these methods may be enhanced using DRO and DRA approaches developed within the context of learning theory; for example, rather than ‘I intend not to drink alcohol when in the pub on Friday with friends’, one might have an implementation intention such as ‘I intend to have longer gaps between alcoholic drinks when in the pub on Friday with friends’ (DRO) or ‘I intend to drink non-alcoholic beers when in the pub on Friday with friends’ (DRA) .

**Achieving maintainable change:** *Contingent Reinforcement, Extinction, Thinning, Schedules of Reinforcement*

A major challenge for interventions to change behaviour is to achieve sustainable change that lasts beyond the end of the planned intervention period. Undoubtedly the main behaviour change technique from learning theory is the use of *contingent reinforcement* i.e. the delivery of reward if and only if the desired behaviour has occurred (positive reinforcement) or the removal of an aversive stimulus if and only if the desired behaviour has occurred (negative reinforcement). At least 10 of the BCTs in BCTTv1 refer to forms of contingent reinforcement, including much of sections 10 (reward and threat) and section 14 (scheduled consequences) (Michie et al., 2013). Most current theories used in health psychology to investigate behaviour change include a construct that refers to contingent consequences for behaviour: for example attitudes toward the behaviour in the Theories of Reasoned Action and of Planned Behaviour or outcome expectancies in Social Cognitive Theory. However these are typically conceptualised as ’beliefs about consequences’ rather than the actual contingent consequences, as summarised in the theoretical domains framework (Michie, Johnston, Abraham et al., 2005). BCTTv1 includes 5 BCTs (10.1, 10.5. 10.6, 10.7 and10.8) that specifically address beliefs about anticipated consequences i.e. incentives in addition to those that refer to actual consequences.

As noted above, there are particular problems in maintaining a change that has ‘removed’ a behaviour as the behaviour is not actually eliminated and there is likely to be spontaneous recovery. However it is also difficult to institute and maintain a new behaviour that is *not* replacing an existing, undesirable behaviour. Failure to maintain new learned behaviours has frequently been mentioned in various contexts including recurrence of pre-intervention behaviours in weight loss maintenance (Dombrowski, Knittle, Avenell et al., 2014) or the loss of new behaviour patterns established using financial incentives when these are withdrawn (Giles, Robalino, McColl et al., 2014). Some insights into these failures may be possible by considering the learning theory processes involved in moving from initial acquisition of learning to maintenance of the new behaviour.

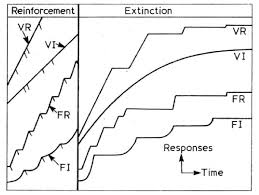
In weight management, the challenge is to maintain weight loss. This problem is clearly recognised in Rothman’s (2000) theory which proposes different processes for the initiation and maintenance phases of behaviour change. However, the behaviours necessary for weight loss maintenance are different from those of weight loss, as otherwise there would be continued weight loss. In Skinner’s terms, the B of the ABC has changed from consuming less calories than are used, to consuming calories equal to those consumed and this might be achieved by changes in calorie intake and/or expenditure. As a result, changes in the identification of antecedents and the implementation of consequences may need to be altered: for example, rewards should be contingent on eating more food or engaging in less exercise than during the weight loss phase. Thus the ‘new’, maintenance, behaviour needs to be learned and some of the failure of maintenance may be due to the lack of a ‘maintenance behaviour’ change programme.

In other behaviour change programmes, such as those offering financial rewards for smoking cessation, the maintenance behaviours are the same as those trained in the programme. However in these programmes, the rewards are typically withdrawn during the maintenance period, and, based on learning theory, an *extinction* schedule is implemented: ”If a behaviour is continuously rewarded and the rewards are then withdrawn, the behaviour should be extinguished”(Johnston & Sniehotta, 2010). In fact this is exactly what one would do to ascertain whether the rewards were having an effect in an ‘AB’ design and in an ‘ABA’ design, one would then reinstate the rewards to achieve behaviour change. In order for financial rewards to result in maintenance of the behaviour, there are at least three methods based on learning theory: the rewards need to continue; *or* rewards need to be withdrawn gradually rather than suddenly; *or* the behaviour needs to be trained using an intermittent rather than a continuous schedule. Learning theory has clearly established evidence for each of these procedures.

First, if rewards are continuous during acquisition of the behaviour and withdrawn immediately on entering the maintenance phase, behaviour should be extinguished unless rewards continue. Clarkson, Turner, Grimshaw et al., (2008) found that a programme of financial rewards for specific dental behaviours (placing fissure sealants on children’s teeth) was effective in increasing the rate of the behaviour. On completion of the research programme, the Chief Dental Officer of Scotland announced that he would implement financial remuneration for this service equivalent to the rewards in the trial, with the result that the behaviour was maintained and thousands of children received appropriate care.

Second, behaviour is more likely to be maintained if rewards are withdrawn gradually, using *thinning*, i.e. increasing the number of responses required to receive reward. For example, in the single case study discussed previously (Johnston, 1987), the participant’s problem behaviour was frequent inappropriate consultations in primary care. In the DRO behaviour change programme, she was rewarded socially for weeks when she did not consult. Rewards were withdrawn as part of an ABA design to test whether the intervention was effective and, as predicted, the problem behaviour quickly recurred at pre-intervention frequency. The DRO programme was reinstated and then thinning of rewards was introduced, gradually extending from a one week interval to a month and then two months. The new behaviour was successfully maintained (Johnston, 1987).

Third, the *schedule of reinforcement* during the acquisition phase will determine the rate at which the behaviour is maintained or lost when rewards are withdrawn. In a continuous schedule, rewards are given contingent on each desirable response i.e. if and only if the behaviour occurs. The alternatives, intermittent reinforcement schedules, do not give reward for each response and are more resistant to extinction when the rewards are withdrawn. The four main intermittent schedules are shown in Figure 1. Variable ratio and fixed ratio schedules reward after a variable or fixed number of responses while variable interval and fixed interval schedules reward after a variable or fixed period. Each schedule has its own characteristic learning and extinction pattern. Variable schedules produce smooth acquisition patterns, while fixed schedules result in the scalloped patterns shown as response rates increase as reinforcement nears. The important feature of the different schedules is that acquisition is faster with ratio schedules and, as shown, extinction is slower and therefore maintenance is more successful, if acquisition has used a variable schedule. Although variable schedules are more resistant to extinction, they may be more difficult to implement in practice. DeLuca and Holburn (1992) illustrate how a variable ratio schedule was implemented for exercising in obese and non-obese boys. An example of a combined fixed ratio and fixed interval schedule is the current pattern of remuneration in primary care for items of service where general practitioners receive remuneration according to QOF (quality outcomes framework) targets. Anecdotally, GPs report that as the deadline approaches, they actively ensure that as many diabetic patients as possible are invited for appointments so that QOF targets are met making the pattern of accumulation of QOF data over each year a typical scalloped curve which accelerates as it nears the reinforcement date. One would predict that rates of completion of QOF behaviours would extinguish rapidly if contingent remuneration were withdrawn unless other rewards occurred.



*Figure 1: Cumulative response rates under different intermittent schedules of reinforcement during reinforcement and extinction: during reinforcement, ratio schedules (VR and FR) show faster rates of acquisition than interval schedules, while variable schedules (VR and VI) show smoother patterns than fixed schedules; during extinction, variable schedules (VR and VI) show greater persistence of responses than fixed schedules. [ VR = variable ratio schedule; VI = variable interval schedule;FR= fixed ratio schedule;FI = fixed interval schedule]*

In sum, maintenance of behaviour change is likely to be stronger if a) the maintenance behaviour have been defined and rewarded, b) the maintenance phase is not implemented suddenly as in an extinction schedule and c) the schedule of reinforcement during acquisition is intermittent rather than continuous.

**Conclusions**

While the last hundred years have seen increasing sophistication in theoretical explanations and methods of investigation, it can be valuable to check that we are not losing the early detailed insights into behaviour change. The earliest pioneers in learning theory aimed to ‘predict and control’ and had less focus on explaining behaviour. Today, policy-makers and practitioners again seek prediction and control of behaviour, while our science additionally continues to seek better explanations.

Learning theory can offer both explanations and methods of improving intervention associated with three current issues in behaviour change intervention. First, behaviour being predictable from earlier behaviour was encapsulated in the Law of Exercise which can explain recurring unrewarded behaviours while evidence of predictability due to stimulus control and the Premack principle offer insights and methods of prevention as well as intervention. Second, the problem of removing behaviour makes sense in the light of evidence on punishment and negative transfer, while methods such as DRO and DRA are helpful in achieving behaviour change. Third, failure to achieve maintainable behaviour change can be explained in some contexts due to inadvertent implementation of extinction and basic knowledge about schedules of reinforcement can assist in planning both the acquisition and the maintenance of a new behaviour. In sum, there may still be more that we can learn from learning theory.

More detail on a wide range of learning theories, (including those of Thorndike, Tolman, Skinner, Pavlov, Hull and Bandura) can be accessed in Carley (2013).

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