Signalling Properties of Reinforcers in Children's Transitions

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Summary

En utvidet mengde forskning tyder på at signalperspektivet tilbyr en alternativ forklaring på en organismes interaksjon med miljøet til det tradisjonelle styrkende synet. Signalperspektivet betrakter forsterkere som veivisere som veileder en organisme til hvor og hvordan flere forsterkere kan skaffes. Så langt har signalegenskapene til forsterkere hovedsakelig blitt studert i operant laboratorier med ikke-menneskelige forsøkspersoner. Denne avhandlingen utvider disse funnene ved å bruke to anvendte eksperimenter med nevrotypiske og nevroatypiske barn og en litteraturgjennomgang av andre anvendte studier.

En litteraturgjennomgang undersøkte fem studier som evaluerte intervensjoner ved bruk av stimuluskontroll anvendte teknikker for analyse av atferd for å utvide repertoaret av sosialt signifikant atferd hos barn med autismespekterforstyrrelse (ASD). Resultatene viser at atferdsendringen som er observert i studiene er bedre forstått fra et signaleringsperspektiv fremfor det styrkende perspektivet.

Studie 2 hadde som mål å forstå mekanismene som kontrollerer atferd under overganger mellom aktiviteter hos barn med ASD. I tilstand 1, der den kommende forsterkerkonteksten var forutsigbar, var de resulterende overgangene til den slankere konteksten lengre enn overgangene til den rikere konteksten. I tilstand 2, hvor forsterkerkonteksten ikke var signalisert, forsvant forskjellene i overgangstider mellom ulike forsterkerkontekster. Disse resultatene tyder på at overgangstider ble kontrollert av utvidede forsterkningsmønstre i stedet for den nyeste forsterkeren. Studie 3 replikerte resultater fra studie 2 og utvidet funn til nevrotypiske barn. Et design for reversering ble introdusert for å validere resultatene ytterligere. Den støttet påstanden om at overgangstiden kan reduseres dersom overganger til den slankere konteksten ikke signaliseres. Begge eksperimentene fremhevet viktigheten av translasjonsforskning, som kan fungere som en bro mellom grunnleggende og anvendt forskning.

Alle studiene støttet nytten av signaleringsperspektivet i anvendte omgivelser, noe som tyder på en fordel for den bredere populasjonen av atferdsanalytikere. Derfor er denne avhandlingen med på å etablere allmennheten i signalperspektivet og er et skritt mot en mer helhetlig forståelse av dette rammeverket i den anvendte konteksten. Jeg oppfordrer til videre

translasjonsforskning på nytten av signalrammeverket utover tolkningen av funn fra grunnleggende eksperimenter.

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1. Introduction

The primary focus of all behaviour analysts is the interaction between the behaviour of organisms and their environment. The three-term contingency (dependency between a response and subsequent potential reinforcers) introduced by Skinner (1938) allowed organising those interactions into measurable units of analysis. It consists of antecedents (A), behaviour (B), and consequences (C). These three terms encompass the stimulus, the response, and the reinforcer. The contingency dictates that the response is reinforced solely in the presence of the stimulus and not at other times. Skinner claimed that, as a result of consistent exposure to this contingency, the behaviour is more likely to occur and be reinforced when the stimulus is present than when it is absent (Sidman, 2008; Skinner, 1969). Skinner noted that: "The environmental control has an obvious biological significance. If all behaviour were equally likely to occur on all occasions, the result would be chaotic. It is obviously advantageous that a response occurs only when it is likely to be reinforced" (Skinner, 1935, p.108).

The definition of each of the three elements derives from the others: An event earns the label of a stimulus if changes in it result in changes to a response; an event qualifies as a response only if it yields a quantifiable consequence and if it undergoes changes when some aspect of the environment changes; a consequence earns the designation of reinforcing only if it brings about a subsequent change in a preceding response. When considered together, these three elements collectively define a unit of behaviour (Mackay, 1991; Moxley, 2004). Each unit constitutes an operant class which is measurable and can be analysed (Skinner, 1935). He then proposed that primary measure of response strength is the rate at which a response occurs. A response occurring at a higher rate purportedly is of greater strength than a response occurring at a lower rate (Skinner, 1935). Response strength refers to the likelihood or probability of a behaviour occurring again in the future in similar circumstances, based on its consequences. In other words, it measures the effectiveness or durability of a learned behaviour.

This framework has served us well because it allowed us to understand how behaviour is shaped by environmental contingencies and how changes in those

contingencies affect behaviour (Sidman, 2008). A plethora of research serves as examples of its usefulness and is discussed in detail in Lattal (1995) and McSweeney and Murphy (2017).

However, while it is still considered by some as "the best way to theoretically understand and to practically control behaviour and therefore the best way to generate useful and accurate theories of behaviour" (McSweeney & Murphy, 2017, p. 39) it has been challenged by the accumulating evidence (Baum, 2012, 2013, 2016, 2018b, 2021; Cowie, 2020; Shahan, 2017; Simon et al., 2020; Timberlake, 1988) that suggests that there are alternative explanations of those interactions that do not require the response strength concept and instead focus on the signalling properties of reinforcers. In this dissertation, I discuss both perspectives and their implications for understanding behaviour and environmental interactions. The results of the studies presented below are intended to showcase two paradigms and invite the reader to consider the signalling perspective as worthy of consideration in their future work.

1.1. Response strength concept and its consequences for understanding reinforcement

Theoretical assumptions

For years, Skinner pushed the field of experimental behaviour analysis forward because, for the first time, behaviour was studied systematically, and the changes in its rates were attributed to experimental manipulations rather than unobservable variables (Skinner, 1935, 1938). Skinner's radical behaviourism was the first branch of psychology to reject inner causality and agency, instead placing behaviour causes in the environment (Zuriff, 1985). Skinner's (1938) concept of response strength has been fundamental in his explanations of behaviour (Baum, 2002, 2011; Cowie, 2020; McSweeney & Murphy, 2017; McSweeney & Swindell, 1999) and served as the basis for the development of theories such as behaviour momentum theory (Nevin & Grace, 2000), which is widely used in experimental and applied settings, mainly to decrease problem behaviour (Podlesnik & DeLeon, 2015). The importance of Skinner's contributions is highlighted throughout *Applied Behaviour Analysis* by Cooper et al. (2019), which is considered a fundamental textbook for everyone attempting

to practice behaviour analysis. “Skinner accumulated significant, if counterintuitive, evidence that behaviour is changed less by the stimuli that precede it (…) and more by the consequences that immediately follow it (…) which are contingent upon it”(Cooper et al., 2019, p.10). This statement led to the development of widely used behaviour modification techniques, which, considering the ongoing advancements in conceptual behaviour analysis, could be refreshed and reflect those changes. Studies included in this dissertation are a step towards this direction.

Skinner’s response strength framework was built upon earlier behavioural theories, such as the law of effect introduced by Thorndike in 1911, stating: "Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur..." (Thorndike, 1911, p. 244).

The theory was criticized by Watson, (1930) who addressed Thorndike’s concept as follows: "Most of the psychologists... believe habit formation is implanted by kind fairies. For example, Thorndike speaks of pleasure stamping in the successful movement and displeasure stamping out the unsuccessful movements" (Thorndike, 1911, p. 206). Besides Watson’s (1930), scepticism about the notion that satisfying outcomes could reinforce responses, it continued to hold sway.

As mentioned above, Thorndike's theory and Watson’s (1913, 1924) influential writings later formed the groundwork for Skinner's (1938) response strength theory. Similarly to Watson (1913, 1924, 1930), Skinner (1938, 1953) considered the science of behaviour as a natural science. In such an approach, changes in behaviour are attributed to its observable interactions with the environment.

However, unlike Thorndike, Skinner distinguished between observation and theory. In one of his papers (Skinner, 1950), he stated: "...the law of effect is no theory. It simply specifies a procedure for altering the probability of a chosen response." Skinner also wrote that: “if the occurrence of an operant is followed by presentation of a reinforcing stimulus, the strength is increased” (Skinner, 1953, p.21). Hence, the law of effect tells us that “behaviours that are stronger are more likely to occur relative to those that are weaker” (Skinner, 1953, p.65), and

the ability to change this strength is unique to reinforcers. Skinner's (1938) law of effect stipulates only that reinforcers strengthen behaviour.

This assumption leads to the first of three main challenges with the response strength concept that affects understanding interactions between behaviour and the environment.

Those shortcomings include a challenge to the concept of temporal contiguity supported by empirical evidence (Baum, 1973, 2012; Rachlin, 2003; Sizemore & Lattal, 1978; Staddon & Simmelhag, 1971) followed by challenges to explanations of negative reinforcement (in particular avoidance) (Baum, 2020), and finally challenges to the scope of the response strength concept which is considered too narrow to capture the complexity of behaviour and environment interactions (Baum, 2003, 2012, 2016; Cowie, 2020; Cowie & Davison, 2020; Shahan, 2010, 2017; Simon et al., 2020).

Before discussing those limitations, it is important to address what is the ontological status of response strength. As noted by Killeen and Hall, (2001) and Simon et al., (2020), response strength is regarded as a hypothetical construct, a concept that is crucially distinguished from intervening variables. Simon et al., (2020), highlighted the importance of such discrimination between intervening variables (defined as based solely on observable data, without any additional implied meaning) and hypothetical constructs (theoretical and potentially represent unobserved entities or processes). Hypothetical constructs possess meanings that go beyond the observable phenomena from which they are inferred. Thus, considering response strength as a hypothetical construct may be troublesome since as noted by Skinner, (1938, 1953), science of behaviour is a natural science and changes in behaviour should be attributed to observable variables. However, response strength can also be conceptualized as a descriptor of behaviour (Nevin, 2012) (discussed in more detail below) serving as an explanatory mechanism. This ambiguity in the ontological status of strength poses several challenges in explaining behaviour and environment interactions and is one of the reasons for introducing a signalling perspective, an alternative approach explaining behaviour without the concept of strength.

Challenges to response strength concept

In the response strength concept, contiguity is considered essential in maintaining responding (Skinner, 1938, 1948). However, many studies (Baum, 2012; Lattal, 1995; Staddon & Simmelhag, 1971) described below suggest that contingency plays a more important role in acquiring and maintaining behaviour. Interestingly, contingency, understood as a functional relation between a signal (environmental event) setting an occasion for behaviour to occur, captures the essence of the signalling perspective and provides a straightforward explanation of behaviour-environment interactions. The troublesome temporal contiguity does not play a role in the signalling perspective the way it does in the Skinnerian response strength concept.

In the superstition experiment, (Skinner, 1948), eight pigeons were placed in an experimental cage for few minutes daily and were delivered food at regular intervals independently of their behaviour. As noted, in six out of eight instances, the resulting behaviours were sufficiently distinct for two observers to easily agree on counting occurrences. The behaviours spanned from one bird rotating counter-clockwise around the cage, the other one completing two or three turns between reinforcer deliveries, or another one consistently thrusting its head into one of the upper corners of the cage, or another two displaying a pendulum motion of the head and body, or other ones extending the head forward and swinging it from right to left, followed by a somewhat slower return, with occasional steps taken during extensive movement. Notably, none of these responses exhibited noticeable strength during the adaptation to the cage or until the periodic presentation of the food hopper (Skinner, 1948).

Skinner (1948) noted that delivery of reinforcers had the impact of conditioning pigeons to react to a specific aspect of the environment rather than simply executing a sequence of random movements. Consequently, all responses became rapidly repeated between delivery of reinforcers, usually occurring five or six times within a 15-second interval. Thus, Skinner (1948), argued that the reinforcer strengthened whatever behaviour preceded it, and pigeons behaved as if there was a causal relation between their random behaviours and food delivery due to the temporal contiguity (temporal proximity between behaviour and subsequent events) between the behaviours and the food delivery.

The study was replicated and extended by Staddon & Simmelhag (1971), who used variable inter-food intervals in addition to fixed inter-food intervals used by Skinner (1948) to analyse the results further and compare fixed-interval schedules that are contingent on responses and those that are not contingent on responses. The experiment further builds on Skinner's (1948) research by carefully documenting both the nature and timing of' "superstitious" activities. The primary focus was on the stable-state adaptation. In their procedure, three different food delivery schedules were implemented: (a) a fixed-interval (FI) schedule independent of the pigeon's response, where the food magazine appeared every 12 seconds, (b) a variable-interval (VI) schedule also independent of the pigeon's response, with the food magazine being presented on average every 8 seconds and (c) an FI schedule contingent on the pigeon's response, where reinforcer delivery occurred for the first key peck that happened 12s or more after the previous reinforcer. Food delivery consisted of 2s access to mixed grain. Pigeons were trained in response dependent and response independent conditions.

Unlike Skinner (1948), Staddon and Simmelhag (1971), recorded pigeons' behaviour throughout the whole inter-food intervals, and not just before the food delivery. Due to this manipulation, they noticed that in the steady state, the behaviour observed under both the FI and the VI could be categorized into two distinct types: (a) the terminal response, which was the consistent behaviour occurring just before food delivery; and (b) interim responses, a variety of activities often occurred before the terminal response during the interval. The terminal response typically started 6-8s after food delivery in the FI procedures, and the interim response lasted about 2s after food in the VI procedure, continuing until the next food delivery. These activities closely resembled what is known as mediating behaviour and they seldom occurred in direct conjunction with food delivery (Staddon & Simmelhag, 1971).

The findings of this experiment support the idea that the 'superstition' scenario typically leads to two specific types of behaviour: interim activities that take place at short and intermediate times after food is given, and the terminal response that starts later in the interval and persists until the next food delivery. This distinction was not always evident from Skinner's initial work (Staddon & Simmelhag, 1971). The authors also proposed that behaviour should not be solely understood in terms of cause-and-effect relationships but also in terms of

statistical associations and adaptive responses. Those results challenge the importance of contiguity between a response and a reinforcer, which is considered a core of Skinner's strength concept (Baum & Aparicio, 2020; Cowie, 2020; Shahan, 2010; Simon et al., 2020).

Nonetheless, the significance of the immediate temporal connection between a response and a reinforcer was emphasized by Skinner throughout his early writings (1948, 1953) and then it was subsequently adopted by other researchers in the field, for example by Peele et al. (1984).

Simultaneously, numerous experiments were conducted using unsignalled delays of reinforcement to investigate the impact of disrupting this immediate contiguous relationship between responses and reinforcers (Critchfield & Lattal, 1993; Lattal, 2010; Lattal & Gleeson, 1990; Podlesnik et al., 2006; Sizemore & Lattal, 1977, 1978). Even though different procedures were used in above mentioned studies, the results reported that introduction of reinforcement delay inherently weakens or loosens the connection between responses and reinforcers, however, immediate contiguity between responses and reinforcers is not the only variable that controls responding (Lattal, 2010).

Baum (1973) also raised concerns about the significance of immediate temporal contiguity between responses and reinforcers in sustaining operant behaviour. He suggested that the impact of the disruption of this temporal contiguity leads to a reduction in the correlation between responding and reinforcement (Baum, 1973).

Considering the contiguity between a response and a reinforcer as a primary process explaining behaviour poses several challenges (Kuroda & Lattal, 2018a; Lattal, 1995), some of which were mentioned by Baum (2012). He suggested that contiguity alone is insufficient to determine a contingency because several combinations of events and their absence need to be experienced for a contingency to affect learning. In his 2012 paper, he illustrated this phenomenon using a detection matrix where two columns represented the presence and absence of Event 1 (e.g., a tone or key pecking) and two rows represented the presence and absence of Event 2 (e.g., food or electric shock).

Table 1: Contingency matrix (Baum, 2012).

	Event 1 Present	Event 1 Absent
Event 2 Present	✓	
Event 2 Absent		✓

Baum (2012) argued that for a contingency to exist, both the conjunction of the two events and the conjunction of the absence of the two events must have a high probability. In other words, according to Baum (2012), a contingency requires a comparison between occasions when Event 1 is present and when it is absent. He emphasised that correlations between the rate of an activity and the rate of a reinforcer (such as food) require multiple comparisons, not just temporal conjunctions. For a contingency to affect behaviour, the organism needs to experience different instances where Event 1 occurs and where it does not occur. Those temporal relations are not irrelevant, but they play a different role than what Skinnerian theory suggests. Skinner attributed direct significance to contiguity, whereas Baum argued that the effect of contiguity is indirect (Baum, 2012). For example, introducing reinforcement delays usually reduces the response rate (Lattal, 2010). It affects the tightness of the correlation (Baum, 2012), but as shown by Lattal and Gleeson (1990), successful response acquisition is possible with delayed reinforcers. The contiguity between a response and a reinforcer is insufficient to acquire or maintain behaviour as initially mentioned by Skinner (1953). However, it can facilitate the learning of contingencies as defined in the contingency matrix (Fig. 1).

Also as noted by Lattal and Shahan, (1997), contiguity and contingency although often intertwined in typical experimental setups are distinct from each other. However, under certain conditions, some argue that contiguity alone can replicate the effects of contingency (Skinner, 1948). Nonetheless, Lattal and Shahan, (1997), concluded that contiguity is not a reliable indicator of contingency. Despite ongoing debates, especially around the concept of ‘superstition’ in behavioural experiments (Staddon & Simmelhag, 1971), the idea that accidental temporal associations between responses and reinforcers play a role in learning persists in certain scenarios, like the changeover delay in concurrent schedules (Lattal & Shahan, 1997). The possibility of purely accidental reinforcement suggests that contiguity cannot accurately reflect a pre-established dependency between behaviour and subsequent events. Although

contiguity may not effectively indicate contingency, it could still be adequate for acquiring and maintaining a response.

Similar conclusions on the importance of contingency and non-contiguity were drawn based on the observations of responding on ratio (schedule based on the number of responses between reinforcers delivery) and interval (schedule based on the time between reinforcers delivery) schedules (Baum, 2018b). Those two schedules are typically used when investigating choice behaviour in human or non-human participants. High response rates are usually obtained on ratio schedules and moderate rates on interval schedules. To help explain these results, the concept of inter-response times (IRTs) was introduced (Ferster & Skinner, 1957). IRT is the time that elapses between two consecutive responses. The differential reinforcement of long intervals explained the long IRTs observed on interval schedules. The longer the IRT, the higher the likelihood of the interval timing out during the IRT and producing a reinforcer for the following response. Consequently, longer IRTs are differentially reinforced, leading to their increased frequency and a subsequent reduction in response rate. Conversely, reinforcement generally has the tendency to elevate response rates in both interval and ratio schedules. However, the opposing influence of differential reinforcement of IRTs is unique to interval schedules, contributing to higher response rates in ratio schedules (Baum, 1989).

Baum (2021) suggested that the IRT explanation of lower response rates on interval schedules is incorrect because it is a prediction that contradicts empirical evidence. According to the Skinnerian view, IRTs should keep increasing until the probability of reinforcer delivery reaches 1.0, resulting in an extremely low response rate for every reinforcer obtained. However, response rates on interval schedules are still moderately high despite being lower than rates on ratio schedules (Baum, 2021). Furthermore, the extreme response rates maintained by variable ratio schedules may not be caused by the differential reinforcement of IRTs but rather the differential reinforcement of response rate because of the increasing reinforcer rate (Baum, 2021).

Additionally, moderately high rates on interval schedules cannot be accounted for without considering the rate at which reinforcers are delivered. When the response rate is low on an interval schedule, an increase in response rate leads to significant increases in the reinforcer rate. However, as the response rate reaches

moderate levels, the reinforcer rate no longer continues to increase. This relationship is described by the interval schedule's feedback function (Fig. 2), which follows a negatively accelerated pattern and approaches an asymptote (Baum, 2021).

A feedback system can be conceptualized as a consequence of the continuous interaction between the organism and its environment (Baum, 1992; Staddon, 1983). The organism's functional relations establish connections between environmental events and behavioural responses. Similarly, the environment's feedback functions establish links between behavioural responses and environmental consequences (Baum, 1992). As noted, equilibrium in this system arises from the ongoing interaction between functional relations and feedback functions. Any brief disturbance to the system leads to a deviation from equilibrium, but once the disturbance is removed, the system readjusts and stabilizes. Changes in either a functional relation (such as a shift in deprivation) or a feedback function (like a modification in a schedule) result in the establishment of a new equilibrium (Baum, 1992). For instance, in an interval schedule, the feedback function exhibits a negative acceleration, gradually levelling off towards a horizontal asymptote, which represents the predetermined rate of reinforcement, particularly at elevated response rates (Baum, 1992).

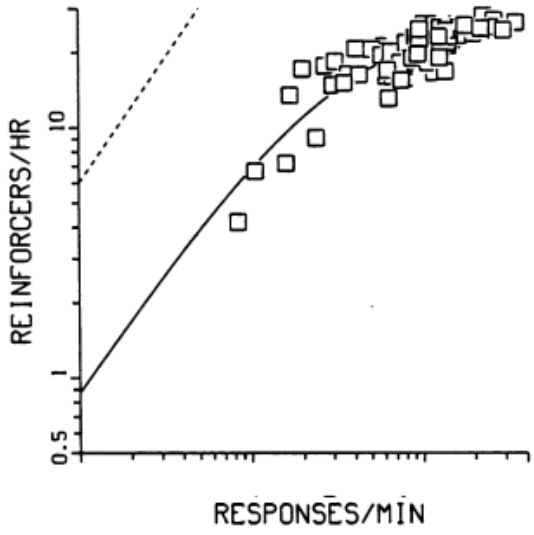

Fig. 1: Interval schedule feedback function fitted in the solid curve to performance on VI 2-min schedule (Baum, 1992).

In conclusion, the challenge with the contiguity between a response and a reinforcer is when it is considered a primary process responsible for both

behaviour acquisition and learning the relations between two stimuli, as it leads to problematic assumptions that were discussed above and also in various other articles (Baum, 2012; Cowie, 2020; Davison & Baum, 2006; Killeen & Jacobs, 2017; Shahan, 2010, 2017). In other words, the contiguity between a response and a reinforcer helps, but the contingency between them is more important due to its functional relation (Williams, 1983). The importance of this functional relation between an environmental event that sets an occasion for a behaviour to occur summarizes the essence of the signalling perspective. Nonetheless, the contiguity is still considered essential in the Skinnerian response strength concept because, according to this concept, the response strengthening occurs whenever a response is followed by the contiguous reinforcer (Skinner, 1938).

The second challenge with the concept of response strength lies in its negative reinforcement (especially avoidance) explanation. For example, when considering the free-operant avoidance phenomenon, one can follow Sidman's (1953) explanation, which relies on delivering unsignalled shocks at regular intervals that can be reduced by regular responding. In other words, the shock rate decreases as the lever pressing rate increases, and if the lever pressing rate is sufficiently high, the shock rate approaches zero. The free-operant avoidance involves two intervals: the shock-shock interval (S-S) and the response-shock interval (R-S). In this procedure, shocks are administered at a rate determined by the S-S interval if a rat does not engage in avoidance behaviour. For instance, if the S-S interval is set at 10 seconds and no lever press occurs for more than 10 seconds following a shock, a shock is delivered at the 10-second mark since the last shock. Each lever press delays the occurrence of a shock within the R-S interval. For example, if the R-S interval is 20 seconds, as long as an organism presses the lever before 20 seconds elapse, no shocks are administered. If an organism receives a shock, the S-S interval begins anew. Therefore, if an animal presses the lever frequently enough, no shocks will be experienced (Sidman, 1953).

To explain Baum's (2020) molar conceptualization of avoidance mentioned below, a brief description of induction will be introduced. As noted by Baum (2020), the concept of induction, was introduced by Segal (1972), and stands in contrast to elicitation. While elicitation depends on a narrow time frame and a direct correspondence between stimulus and response, induction involves a temporally extended relationship. In the context of induction, the occurrence of a

particular event within a given context leads to a prolonged increase in time spent engaging in the induced activities within that context. It encompasses not only elicitation but also more protracted phenomena (Baum, 2020).

The challenge with the contiguity account of negative reinforcement is that it relies on the premise that, similar to the positive correlation between a reinforcer rate and a response, a negative correlation can be observed between responding and the shock rate (Baum, 2020). However, the free-operant avoidance procedure depends on the shock-rate reduction, not the shock rate itself. If we consider that reinforcers can have functions other than strengthening, namely signalling, the explanation of free-operant avoidance becomes more straightforward. Baum (2020) suggests that operant behaviour increases or decreases not because it is strengthened or weakened by the reinforcers that follow it but because of the covariance between a behaviour and an environment. Reinforcers such as electric shock in avoidance procedure induce (set occasion for a behaviour to occur) the associated activities, such as avoidance behaviour in Sidman's (1953) procedure. In other words, an electric shock induces avoidance activity and does not strengthen the lever pressing to reduce a shock rate. Thus, the signalling properties of reinforcers in the avoidance procedure set an occasion for an avoidance behaviour to occur. For example, receiving an invitation to a meeting with an individual one does not like sets an occasion for rather than strengthens the behaviour that results in avoiding that meeting. Hence, avoidance activity is in negative covariance with the reinforcer that induces it, like an electric shock in an avoidance procedure or an invitation to a party one does not want to attend.

The third shortcoming of the Skinnerian concept of response strength is that it does not consider wider environmental aspects (exposure to repeated regularities in the environment either through ontogenetic or phylogenetic history (Baum, 2012) that may influence behaviour and, hence, could lead to a more reliable and thorough understanding of behaviour-environment relations.

Shahan (2017) suggested that reinforcers serve as a means to measure an organism's ability to learn about predictive relationships in its environment. This is achieved by adjusting performance based on the predicted outcome and an organism's appropriate motivational or behavioural state at that moment. These significant events may hold importance due to their evolutionary significance. Events may also gain significance by serving as signals to guide an organism

towards obtaining or avoiding relevant events (like in free-operant avoidance procedure) based on where, when, or how they occur. For example, an empty berry patch in the forest signals to a hungry, foraging organism that another spot must be found to fulfil its current disposition.

Shahan (2017) also suggested a more comprehensive approach towards reinforcement that would include factors such as temporal context, probability, and alternative sources of reinforcement. He also indicated that behaviour analysts should move beyond the narrow focus of Skinnerian response strength to explore ways in which reinforcers affect other aspects of behaviour such as response allocation and choice.

Palmer (2009) suggested a response competition concept, which can be considered as Skinnerian approach to response allocation. It states that if two incompatible responses are roughly equipotent, only one will be emitted and competing response will be inhibited (Palmer, 2009). He proposed that every response exerts a suppressive influence on all other responses within the same response system, and this inhibitory impact is directly proportional to the strength of the response. He also noted that if strengthened response potential involved such inhibition, a positive feedback loop would emerge: the strongest response would impose the most potent inhibitory effect on related responses. Consequently, not only would competing responses experience some degree of suppression, but the counteractive inhibitory impact from those other responses would also be diminished. Consequently, mutual inhibition would result in the dominance of a singular response, averting the occurrence of response blends. He suggested that the bottleneck analogy could be elucidated through this perspective (Palmer, 2009).

Palmer's (2009) bottleneck analogy was challenged on the grounds on its explanatory power by Simon et al. (2020, p. 686), stating that "competition appears to result from a conflation of ultimate and proximate explanations, in the sense that a mechanism, which can at best explain how behaviour comes about, is described in a behaviour analytic vocabulary developed to answer the question why behaviour occurs". As a solution they proposed considering response allocation from a molar perspective (elaborated on below) (Simon et al., 2020).

Considering the limitations mentioned above, an alternative approach that shifts the focus from the response-strengthening properties of reinforcers to their discriminative function was introduced (Cowie, 2020; Shahan, 2010, 2017; Simon et al., 2020). By doing so, the response-strengthening properties of reinforcers give way to their guiding or signalling effects, which are placed in the spotlight. There are several terms, used interchangeably, to describe reinforcers as discriminative stimuli such as ‘signals’(Cowie, 2020), ‘signposts’ (Shahan, 2010), ‘means to an end’ (Shahan, 2010) and ‘inducers’ (Baum, 2018b) and they all capture the essence of their signalling effect on the behaviour. This dissertation uses the term “reinforcers” to avoid possible confusion for behaviour analysts raised in the Skinnerian tradition.

Throughout this dissertation, the term ‘reinforcers’ will denote events that signal to organisms what behaviour will lead to advantageous or disadvantageous outcomes. However, the aim is to go beyond the Skinnerian associations of ‘reinforcing’ or ‘strengthening’ as used in material sciences (Shahan, 2017, explains this notion in more detail). While the signalling effects of ‘reinforcers’ are discussed, the term ‘reinforcement’ is explicitly reserved for the process of strengthening in the sense described by Skinner (1938), which does not fit in the signalling perspective.

Moreover, in the signalling perspective, an alternative proposed in this dissertation, the term “reinforcer refers to events that hold value for the organism” (Cowie, 2020, p. 355). Therefore, in the signalling perspective, the power of a reinforcer to bring about behavioural changes arises from its potential to fulfil the organism's current needs, either by directly influencing the organism's disposition or by indicating a future in which those needs can be met. Disposition may initially seem inherent to the organism but can also depend on its recent interactions with the environment (Cowie, 2020).

1.2. Alternative approach focused on signalling properties of reinforcers

Empirical evidence

The distinction between the signalling and the strengthening views becomes evident through their respective guiding metaphors that stem from each paradigm's distinct ontological assumptions. The molecular view (Baum, 2001, 2003, 2012, 2013) emphasises the concept of strength, whereas the signalling view (Davison & Baum, 2006, 2010) focuses on the signalling function of reinforcers. The signalling view is a part of the molar perspective (Baum, 1989, 2001, 2003, 2012).

Molar perspective was introduced by Baum (2002, 2011, 2012, 2013, 2016), as an alternative to the traditional Skinnerian view (Baum, 2001). In this view behaviour is considered as activities extended through time, which occupy the whole time available (Baum, 2012, 2018a, 2018b). The organisms spend their whole time behaving and by focusing on a small snapshot of behaviour (discrete response) one might not accurately account for what the activity is (Baum, 2024, 2013, 2017). For example, if one observes a pigeon in its home cage for a brief moment, it would be difficult to determine whether its behaviour (head turning) is a part of its recreational activity, grooming, or perhaps eating or drinking. Only observation over longer period of time would allow to determine that. Thus, even though counting discrete responses had proven useful is some experimental work (Kuroda & Lattal, 2018a; Peele et al., 1984) adopting molar perspective allows to capture behaviour more accurately (Baum, 2012; Cowie, 2020; Shahan, 2017).

In molar view, changes in behaviour allocation result from both induction (elaborated on above) and correlation. Induction encompasses behaviours like adjunctive, interim, and terminal activities, which are induced by the occurrence of food or other phylogenetically important events (PIEs). This process is similar to stimulus control, where there isn't a direct one-to-one link between the behaviour and its inducing event. Considering some forms of stimulus control may arise from phylogeny, induction, and stimulus control could be seen as analogous, with a PIE functioning as a signal (Baum, 2002, 2018a). There's substantial evidence suggesting that a PIE can induce a range of PIE-related behaviours (Baum, 2012). Furthermore, stimuli associated with PIEs can become

conditional inducers (stimulus/signalling function), and because the induced behaviour is in covariance with the phylogenetically important event (reinforcing function) such as food, we observe more of it as long as it satisfies the organism current needs (Baum, 2024, 2018a). For example, food is a conditional inducer (signalling function) for a hungry organism; the covariance is positive when the hunger is satisfied by obtaining food (phylogenetically important event).

Thus, signalling perspective is a part of the molar view concerned mainly with the signalling properties of environmental events and how those signalling properties signal to the organism where and how more of them can be found based on extended past experience (Cowie et al., 2017; Davison & Baum, 2006, 2010). The signalling properties of reinforcers were especially well illustrated in studies where given a prior food delivery subsequent food deliveries were more likely signalled by where food delivery had not occurred (Davison & Baum, 2006, 2010; Krägeloh et al., 2005) (studies discuused in detail below). This resulted in preference pulses primarily directed toward the alternative key (not the just productive key). Those findings motivated the shift in considering conditional reinforcers effects as signalling effects and to extend this perspective to seeing potential primary reinforcers effects similarly as signalling effects (Davison & Baum, 2006, 2010). In many preparations, food delivery signals more instances of food deliveries for the same behaviour, leading to the repetition of that behaviour. However, in procedures like those described by Davison & Baum, (2006, 2010) and Krägeloh et al., (2005), food delivery signals a decrease in available food, prompting a shift in behaviour.

Baum (1973) laid the groundwork for signalling perspective when he proposed that temporal correlation, rather than direct pairing, serves as a comprehensive framework for understanding the consequences of stimuli like food and electric shocks. Pavlovian or respondent procedures, which associate a stimulus with food or shock, must also associate the absence of food or shock with the absence of the stimulus to be effective. Therefore, the differential predictiveness of the stimulus produces its impact (Baum, 1973). Signalling properties of reinforcers emerge within procedures that correlate specific activities with the occurrence of food or shock. Considering food or shock as predictive of themselves allows to conceptualize the effects of common procedures establishing correlations between these signals and the likelihood of their recurrence. By combining these signals with predictiveness, these events guide behaviour towards or away from

them, laying the groundwork for the observed effects commonly referred to as reinforcement and punishment (Davison & Baum, 2006).

As mentioned in various studies, (Cowie et al., 2011, 2017; Cowie & Davison, 2016; Davison & Baum, 2006, 2010), when an organism encounters situations where food or shock signals its own unavailability in correlation with alternative activities, and behaviour switches towards the likely source of food or the activity avoiding shock those observations can be generalized. The overarching principle, beyond a mere strengthening and weakening by reinforcers, could be that signals predicting future reinforcers' occurrences, guide behaviour towards activities producing them (Davison & Baum, 2006, 2010).

This leads to a consideration of alternative understanding of reinforcers' role in behaviour analysis. Changes in behaviour are determined by the signalling properties of positive or negative events themselves, or signals of these events. The contingent presentation of presumed reinforcers can either enhance behaviour (if they indicate more of the same events) or diminish it (if they signal a reduction of the same events) (Cowie et al., 2011; Davison & Baum, 2006, 2010). For instance, in an environment with a limited number of reinforcers, these reinforcers may decrease one type of activity while encouraging alternative activities. This was well illustrated by the foraging example mentioned above where a fixed, discernible number of berries in a patch leads animals to leave the patch once that number is reached. If the number is larger and less distinguishable, animals might leave upon encountering a different stimulus condition, like a period without reinforcers.

In experimental settings where sessions conclude after a set number of food deliveries, the number of deliveries might signal the absence of further food in that setting and possibly the presence of food elsewhere, like post session feeding in the home cage. With negative consequences like timeout, long-term ineffectiveness may result if it signals a period with a higher likelihood of reinforcers or a lower chance of punishment post-timeout (Cowie et al., 2011, 2017; Davison & Baum, 2006, 2010). Thus, the signalling perspective highlights the need for careful consideration in ensuring that reinforcers truly indicate more of the same and that punishers don't inadvertently signal times of increased reinforcer availability.

The Skinnerian strengthening perspective is usually called the molecular view (Baum, 2001, 2012; Cowie, 2020; Kuroda & Lattal, 2018; Shahan, 2017) because it focuses on momentary discrete responses and stimuli and the contiguity between them. The strengthening view relies on momentary (discrete) events (Baum, 2002, 2012, 2018b, 2021), often resorting to hypothetical causes when no causes are observable (like the unobservable reinforcer in the two-factor theory explaining avoidance). In signalled avoidance experiments, a signal such as a sound or light signals an electric shock, prompting the subject to react to avoid the shock. The underlying theory suggests that the signal induces 'fear,' and that the avoidance behaviour serves to alleviate this fear immediately. However, this theory faced criticism due to the unobservable nature of both the supposed fear and its alleviation, making empirical testing challenging and unfeasible (Herrnstein, 1969).

Unlike the Skinnerian view, in the signalling perspective repeated exposure to patterns in the environment, whether in one's personal experiences or evolutionary history, leads to the control of our behaviour in a way that aligns with anticipated future events (Cowie, 2020; Simon et al., 2020). For example, eating pizza daily for a few months while abstaining from physical activity will likely lead to weight gain. Those environmental regularities allow behaviour to adjust according to the likely future events (keep eating pizza if weight gain is a goal).

Thus, in the signalling view, behaviour is governed by its relations with the environment extended through time. Together, behaviour and environment make up a feedback system in which the environment offers feedback on behaviour in the form of effects that change the behaviour flow. For example, drinking water is part of an extended activity pattern that aims to maintain health. Health-maintaining goals consist of other activities such as physical activity, eating, sleeping, meditation, etc. All those activities take time and compete with other activities. Thus, the time allocation for each activity is based on the organism's choice to fulfil its current disposition or need based on extended past experience and current environmental signals. This correlational control is future-oriented and generalised from past experiences. It occurs through the relationships between stimuli, behaviour, and reinforcers (operant) and between stimuli, other stimuli, and behaviours (respondent). Signals, which are events that reliably precede other events, allow behaviour to adjust based on expected future

conditions. These signals encompass environmental stimuli, behaviours, reinforcers, and physiological occurrences. Hence, building on the previous example, a water fountain signals a thirsty organism to drink water, part of health-maintaining activity. Memory plays a role by allowing signals to influence behaviour even when physically absent. The memory of an signal serves as a bridge when the response leading to a recent reinforcer indicates the likely location of the next one or when a briefly presented stimulus in a trial predicts the correct choice later in the trial (Cowie, 2020; Cowie et al., 2017).

Signals can control all types of behaviour due to their relationship with future events. They can indicate futures that necessitate specific behaviours to achieve desirable outcomes (operant) as well as futures where certain conditions occur independently of behaviour (respondent) (Cowie, 2020). Hence, signals control all behaviour (respondent and operant), and they do so because of their apparent relation to some subsequent event. The function of the response, whether operant or respondent, is to act on the environment to enhance future conditions. The arrangement of stimuli and responses in an environmental pattern (stimulus: stimulus: response or stimulus: response: reinforcer) does not impact the underlying processes that enable it to exert control. Thus, in the signalling perspective, distinction between operant and respondent behaviours lies solely in the sequence of events that control behaviour; they are not governed by fundamentally different mechanisms (Cowie, 2020; Cowie et al., 2017).

In the signalling perspective, responses are produced to act on the environment and maximise favourable future conditions. The control of signals on behaviour is often imperfect and depends on how well they predict future conditions and an organism's ability to detect its relations to future conditions (Cowie et al., 2017; Cowie & Davison, 2016).

This imperfect control of the signals was well captured by the detection-theory model (Davison & Jenkins, 1985), which proposed that individuals may not perfectly differentiate between responses that lead to different reinforcers, measured as reinforcer-contingency discriminability. This is particularly true for situations where individuals must detect and discriminate between different signals.

Elliffe and Davison (2003) suggested that such divided stimulus control is governed by relative reinforcers (reinforcers available on one alternative relative to all available reinforcers on both alternatives) and external stimuli. It is usually studied using a standard conditional discrimination procedure, in which two distinct stimuli (such as different colours of light) serve as signals for different reinforcement contingencies in a subsequent choice procedure.

For example, Davison and Baum, (2006), investigated the discriminative function of conditioned reinforcers using a choice procedure with frequently changing food-delivery ratios to explore the impact of introducing additional response-dependent stimuli on subsequent choices. The added stimuli included a magazine light, often paired with food delivery, and a three-second key light colour change, which was not associated with food delivery. They tested these across seven different food-ratio components, where the ratio of response-dependent key light stimuli on the two concurrent schedules had either a positive correlation (+1) with the food ratio in some conditions or a negative correlation (-1) in others (Davison & Baum, 2006).

The findings indicated that both the paired magazine lights and the unpaired key light stimuli led to similar local shifts in choice behaviour. The direction of these shifts was influenced by the type of correlation: a +1-correlation led to a preference for the recently presented stimulus, while a -1 correlation shifted preference towards the alternative that had not just produced the stimulus. They concluded that these stimuli functioned as discriminative signals, indicating the future availability of food from a particular alternative, rather than acting as conditional reinforcers. This was the case even for the magazine light, which was paired with food delivery (Davison & Baum, 2006). However, if the stimulus predicted food on the other option, the pulse would occur on the other option. As a consequence of a process of strengthening by reinforcement, one would expect that the pulse occurred on the last reinforced option instead. This did not happen. In other words, since the correlation of the stimulus with the location was important and pairing the food with the stimulus did not matter, conditioned reinforcer effects seem to be best understood as signalling effects.

To further investigate findings from the 2006 study, Davison and Baum (2010) investigated the effect of contingencies surrounding key light stimuli within the frequently changing food-ratio procedure. They suggested that if the stimuli were

functioning as conditional reinforcers, the presence or absence of a response-stimulus contingency should influence whether they produce a post-stimulus increase in choice behaviour. Thus, Davison and Baum (2010) arranged four different procedures where the stimuli were (1) presented noncontingently; (2) presented noncontingently but with a requirement to respond to turn them off; (3) contingent upon responding with an additional contingency to deactivate them; and (4) similar to (3), but also with the stimuli concurrently paired with food delivery. For each of these procedures, Davison and Baum (2010) established both positive and negative correlations between stimulus ratio and food ratio, mirroring the methodology of the 2006 study.

The findings from Davison and Baum (2006), on the effect of stimulus-ratio to food-ratio correlation on choice behaviour following stimulus presentation were successfully replicated. They suggested that this correlation determined the subsequent choice pattern: a positive correlation led to increased choice towards the alternative that had recently provided the stimulus, both in the short and long term, whereas a negative correlation resulted in post-stimulus choice favouring the alternative that had not recently provided the stimulus (Davison & Baum, 2010).

Interestingly, this directional shift in choice was unaffected by whether the stimulus onset or offset was contingent or noncontingent, or whether the stimulus was paired with food or not. Furthermore, consistent with previous findings where magazine light paired with food had a similar effect (Davison & Baum, 2006), the observed directional change was independent of whether the paired stimulus occurred in the food magazine or on the key. Consequently, the post-stimulus preference direction suggests the absence of conditional reinforcement of preceding responses in both Davison and Baum (2006) and Davison and Baum (2010). Instead, the post-stimulus behavioural change reflects a signalling effect, with the stimulus indicating the likely location of the next food which is also in line with the 2006 findings (Davison & Baum, 2010).

As mentioned by Davison and Baum, (2010), the results reported by Bolles, (1961) also highlight the signalling properties of reinforcers. Bolles (1961) trained rats in two distinct choice scenarios, both involving two levers that, when pressed, dispensed food at scheduled intervals, accompanied by a clicking sound. In the first condition, the likelihood of the same lever delivering food again was

higher if it had just done so. Conversely, in the second condition, the lever that did not produce food recently was more likely to deliver food in the following delivery. In the first condition rats continued to press the lever that had just delivered food, while in the second, they switched to the other lever after receiving food. Post-training tests in an extinction condition, where only one lever produced the click without food, revealed distinct preferences. Rats trained under the first condition favoured the clicking lever during extinction, whereas those from the second condition preferred the non-clicking lever. Contrary to reinforcing the preceding behaviour, the click prompted the rats to engage with the alternate lever. The findings were interpreted as evidence that stimuli linked with reinforcers primarily guide behaviour rather than directly strengthen it.

The influence of a signal on behaviour depends on the significance of the future it represents and its relevance to the organism's current state (Cowie, 2020). If the signal indicates valuable events in the present, it will trigger behaviours aligned with those events; however, the signal indicating unimportant events will have no impact. In cases where multiple signals indicate different future conditions based on the organism's disposition, the controlling signal is determined by the organism's disposition (Cowie et al., 2011). For example, a water fountain will exert control of an organism’s behaviour only when the organism is thirsty. The signal occasions behaviour that brings the organism closer to the most valuable future (Cowie et al., 2011, 2017). Each signal can be connected to multiple correlations, i.e., food may signal either more food based on extended past experience or may signal biological processes such as digestion. In situations where the structure of the environment fosters unavoidable competition among signals, it may lead to suboptimal outcomes. For instance, a token paired with food can trigger food-seeking behaviours even when those behaviours delay the delivery of the subsequent food (Cowie, 2020).

The signalling properties of reinforcers are well illustrated by the response patterns on fixed-interval (FI) and fixed-ratio (FR) schedules. The absence of or decreased responding following food delivery on FI and FR schedules is explained by each reinforcer signalling to an organism the beginning of a period when no reinforcers will be delivered as long as the schedule alternates in such a way that the last reinforcer and schedule value predict the next one (Cowie et al., 2011; Cowie & Davison, 2016). This phenomenon was first observed by Ferster and Skinner (1957) and called a ‘priming run’ (in other words it is a pause after a

reinforcer delivery), then the absence of a reinforcer after a number of responses have been made or after a fixed time elapsed serves as an environmental signal.

In Krägeloh et al. (2005), this phenomenon was mainly observed in conditions with short same-key reinforcer sequences. Their study explored the impact of consecutive reinforcer sequences derived from the same response key on local preference within concurrent variable-interval schedules in pigeons. With an average overall reinforcer rate of one every 27 seconds, they scheduled reinforcers dependently, manipulating the probability of arranging a reinforcer on the same alternative as the previous one. Despite maintaining an overall 1:1 reinforcer ratio throughout the experiment, they varied the average lengths of same-key reinforcer sequences across conditions by adjusting the conditional probability from 0 to 1. Consequently, some conditions featured frequent changes in reinforcer locations, while others exhibited prolonged sequences of same-key reinforcers. In one of the conditions, pigeons were presented with two keys which produced food pellets. Food was contingent on switching pecking location, i.e. it was contingent on a pigeon pecking the right key if pecking on the left key was recently reinforced (Krägeloh et al., 2005).

Krägeloh et al. (2005) found that when a delivery of food indicated the absence of subsequent food, the preference generally shifted towards the alternative, or the non-recently productive, key. This observation highlights signalling effects of reinforcers. In many experimental setups, the delivery of food signals the likelihood of more food being delivered for the same behaviour, leading to a repetition of that behaviour (Baum & Davison, 2004; Davison & Baum, 2006, 2010).

Hence, those findings are more straightforwardly explained by the signalling perspective. Rather than increasing responses that occurred prior to food delivery, food delivery (reinforcers) increased responding on the other alternative if food delivery signalled that the other alternative was more likely to produce the next food delivery. If the most recent behaviour had been strengthened, the pigeons would have pecked the exact location again. However, the (more extended) pattern of food availability contingent on not having pecked in the same location (where the last food delivery came from) signalled to the pigeons where food would be available next.

This behavioural switching pattern makes sense from a phylogenetic perspective when organisms consume resources that deplete in a specific location after one act of consumption. Consuming the resource signals that a location switch will generate more of that resource rather than staying where the behaviour was successful (i.e., reinforced) and the food depleted (Baum, 2012; Cowie et al., 2017; Davison & Baum, 2006, 2010; Krägeloh et al., 2005).

Those results suggest that while reinforcers can develop signalling functions and locally control preference, different aspects of reinforcers can vary in their ability to acquire this function. Specifically, the location of the reinforcer may exert a stronger influence as a controlling variable than its magnitude (Cowie et al., 2017).

Similar conclusions were drawn from an applied study (Cowie et al., 2021), where children played a game where one response could produce a reinforcer. They used a plastic storage container with drawers as apparatus. Out of the four drawers used during the study, the top two (Row 1) were used during Choice 1 and the bottom two (Row 2) during Choice 2. Right and left drawers were each different colours, assigned randomly across participants. Both colours were replaced with new colours at the start of each condition to reduce the likelihood of any carryover effects across conditions. During daily testing sessions, participants engaged in a successive-choice game involving four drawers. In each trial, they made two sequential choices: initially between the two drawers in Row 1, followed by a choice between the two drawers in Row 2. The probability of a reinforcer being in the left or right Row 1 drawer remained constant at 0.5. In Row 2, the likelihood of the reinforcer being in the same drawer as in Row 1 varied based on the condition. This probability remained constant within a single testing session. Specifically, the probability of a Row 2 reinforcer being in the just-reinforced (Row 1) location was 0.9 in the stay condition, 0.5 in the control condition, and 0.1 in the switch condition. Each condition consisted of 10 testing sessions. Participants played the choice game according to a specific condition (i.e., Row-2-reinforcer probability) for 10 consecutive testing sessions before transitioning to another condition for the next 10 sessions. This pattern continued until all three conditions were experienced across 30 daily (weekday only) sessions for each participant.(Cowie et al., 2021).

When participants correctly chose the Row 1 drawer with the reinforcer, they were given 15 seconds to interact with or consume the item, after which it was taken away. Conversely, if they chose the Row 1 drawer without the reinforcer, the experimenter encouraged a second attempt. The reinforcer was then removed without any social interaction with the participant for a 15-second period. After this interval, the participant was prompted to select a drawer in Row 2. A correct choice in Row 2 allowed them again 15 seconds to interact with or consume the item. However, if the choice was incorrect, the experimenter opened the actual drawer with the reinforcer and showed it to the participant, then removed the item and started a 45-second intertrial interval (Cowie et al., 2021).

Cowie et al. (2021) observed that in both conditions children switched from the just reinforced response to the alternative one, which is difficult to explain based on the concept of response strength, which would predict the repetition of the last response occurring before the reinforcer. Instead of strengthening the last response, the reinforcers presumably signalled that switching is required to obtain the next reinforcer. Hence, the signalling perspective offers a more straightforward explanation of the obtained results. A strengthening perspective would be a reasonable explanation if the researchers had observed less switching in the switch condition and more switching in the stay condition. Thus, unlike the Skinnerian view, the signalling framework allows us to conceptualise all behaviours regarding the same underlying source of control, namely the environment's structure without restoring the Skinnerian concept of response strength.

The signalling perspective’s usefulness is supported by results from basic studies (e.g., Baum, 2018; Cowie et al., 2011; Cowie & Davison, 2016; Shahan, 2010, 2017a) and applied studies (e.g., Cowie et al., 2021; Wood & Simon, 2023). The signalling perspective should be considered when extended contingencies and correlations between the behaviour of organisms and extended environmental patterns explain results better than the Skinnerian concept of strength.

1.3. Transitions between activities

1.3.1. Transitions in the applied context

Transitions between activities are an integral part of everyday life. The average child spends 25% of their time transitioning between different tasks (Sterling-Turner & Jordan, 2007). As Sainato (1990) suggested, coping with the environment, which includes transitioning between activities throughout the day, is a developmental goal for preschoolers. Children with ASD find transitions more challenging than neurotypically developed children, requiring more time and practice to master them (Jessel et al., 2016). Furthermore, transitions are commonly found aversive and may be accompanied by problem behaviour such as tantrums and aggression (Sterling-Turner & Jordan, 2007) in children with ASD.

Such challenging behaviours limit instructional time and disrupt classroom activities, negatively impacting the educational experience. Thus, developing interventions that can improve behaviour during transitions between activities is essential. The ability to successfully transition between tasks can significantly improve independence and adaptability in children with ASD and their overall performance (Sterling-Turner & Jordan, 2007).

Transitions to the leaner context are usually associated with more challenging behaviour than transitions to the richer one (Jessel et al., 2016). Since transitions to less reinforcing activities while engaged in the preferred one are inevitable in everyday life, interventions to help children transition effectively are crucial. Possible treatment suggestions stem from the results of Study 2. This study showed that introducing unsignalled transitions or broadening the array of reinforcer contexts (introducing moderate context in addition to lean and rich ones) available in the signal transitions can help children with ASD transition between activities more effectively.

1.3.2. Transitions and the signalling perspective

Transitions between activities are studied in basic (Langford et al., 2019; Perone & Courtney, 1992; Toegel & Perone, 2022) and applied (Jessel et al., 2016; Sterling-Turner & Jordan, 2007) studies with nonhuman and human participants. Transitions between different reinforcer contexts (typically rich and lean) can be signalled (Perone & Courtney, 1992; Toegel & Perone, 2022) or unsignalled (Jessel et al., 2016) (in one of the conditions) and the results from both type of studies confirm that both procedures can be successful in reducing time spent transitioning and problem behaviour (Brewer et al., 2014; Jessel et al., 2016) associated with transitions.

Toegel & Perone, (2022) studied the 'advance notice' as a possible intervention to reduce time spent transitioning to signalled, unavoidable leaner reinforcer context. In their study, flashing of the house light served as a signal (advance notice) signalling to the pigeon upcoming lean reinforcer context.

They used multiple schedules with two FR components, where the lean component produced brief access to food, whereas the rich component produced longer access to food (Toegel & Perone, 2022). In conditions where flashing of the house light served as signal during rich-lean transitions they observed extended pausing, and hence longer transition time. In conditions where signal (flashing of the house light) could produce access to either rich or lean reinforcer context, it did not affect the transition time. The authors concluded that signal paired with the upcoming reinforcer context partially determined the transition time.

Similarly, in an applied preparation for studying transitions between activities (Jessel et al., 2016), children transitioned between four playmats arranged in a square with two playmats (blue and red) representing lean reinforcer context and two playmats (green and yellow) representing rich reinforcer context. In one condition, a colour of the mat served as a signal to the child signalling the upcoming reinforcer context (either lean or rich). In another condition, the colour of the mat did not reliably signal the upcoming reinforcer context (either lean or rich). The rich-lean transition times in the signalled condition were longer than those in the unsignalled condition. Jessel et al., (2016), concluded that the upcoming reinforcer context determined the transition time.

Those results fit in well with what was reported by Davison and Baum, (2006, 2010), and Bolles, (1961) (all studies are explained in detail above), highlighting that reinforcers have predominantly signalling function rather than strengthening. Both in basic (Langford et al., 2019; Perone & Courtney, 1992; Toegel & Perone, 2022) and applied (Jessel et al., 2016) studies the length of transitions was at least partially determined by the upcoming reinforcer context, if signalled.

Jessel et al., (2016)'s participants transitioned faster when a signal such as a colour of the playmat reliably signalled access to rich reinforcer context (Condition 1). This did not happen when the colour of the playmat reliably signalled lean reinforcer context. Results reported by Jessel et al., (2016) indicate that signals influence behaviour. The likely future controlled children's behaviour (the toy they were going to signalled by the mat colour) rather than the immediate past (the toy they were coming from) when clear signals (mat colours with 100% correspondence to toy) were present. In this study, extended past experiences (playing with preferred toy on the rich reinforcer context mat or playing with the less preferred toy on the lean reinforcer context mat) formed the building blocks for the present behaviour (transitioning faster or slower to the upcoming reinforcer context based on the reliably available signals in the signalled condition) and exerted control over it instead of the immediate past.

In Jessel et al., (2016), and in Studies 2 and 3 participants were given verbal and visual (Studies 2 and 3) instructions. These instructions were minimal and consisted of a statement "go to *colour of the mat*" in Studies 2 and 3 and visual display of the colour of the mat on the tablet. The instructions were also a source of control over participants' behaviour (presumable without instructions, goal behaviour wouldn't be defined - or it would have taken participants much longer without the instructions). However, instructions were identical in both conditions in both studies. Thus, there is no reason to indicate that the instructions are responsible for the observed differences. Instructions may have interacted with the effect of the mat colour reliability but that is impossible to determine based on the design because instructions were "a variable held constant".

Conceptualizing transitions between activities with the signalling perspective as a theoretical background is particularly useful when discussing signalled transitions between different reinforcer contexts. For example, signalled transitions to the richer reinforcer context are always faster than those to the

leaner one (Jessel et al., 2016; Langford et al., 2019; Perone & Courtney, 1992; Toegel & Perone, 2022). The most straightforward explanation of those findings is the signalling properties of reinforcers that guide behaviour to the likely future where more of them can be obtained, such as a green and yellow playmats in Jessel et al. (2016), that signalled upcoming rich reinforcer context.

Some similarities can be observed between research on choice procedures with frequently changing delivery ratios (Baum & Davison, 2004; Davison & Baum, 2006, 2010; Krägeloh & Davison, 2003) and studies on transitions between activities (Jessel et al., 2016; Langford et al., 2019; Perone & Courtney, 1992; Toegel & Perone, 2022; Wood & Simon, 2023). In both procedures the signal signalling the upcoming reinforcer's location (in a choice procedure), or it's type (rich/ moderate/ lean in transitions) exerted control of behaviour. For example, signalling properties of reinforcers can explain more straightforwardly the switching between two keys during choice procedures. In these procedures pigeons switched to another alternative instead of pecking on the just reinforced alternative (Davison & Baum, 2006, 2010; Krägeloh et al., 2005; Krägeloh & Davison, 2003). Thus, similarly to Jessel et al., (2016), extended past experiences (switching away from just reinforced alternative) formed the building blocks for the present behaviour (pecking on the alternative that was not just reinforced) and exerted control over it instead of the immediate past.

In conclusion, findings from both transitions between different reinforcer contexts and choice procedure studies mentioned above are more plausibly understood from the signalling perspective than from the strengthening perspective. The just reinforced alternative in a choice procedure and the previous (just reinforced) reinforcer context in transitions can reliably explain observed behaviour, which was primarily controlled by the future possible reinforcers based on extended past experience (Cowie et al., 2017; Cowie & Davison, 2016, 2020).

1.4. Importance of translational research

As mentioned throughout the literature (Critchfield, 2011; Kyonka & Subramaniam, 2018; Mace & Critchfield, 2010; Pilgrim, 2011; Poling, 2010), quality translational research in behaviour analysis is important for both basic and applied researchers.

According to Poling (2010) and Critchfield (2011), experimental analysis of behaviour (EAB) should focus more on phenomena important to everyday social issues instead of solely focusing on fundamental principles of behaviour and theory. Perone (1985) mentioned that the number of basic research citations in applied studies far exceeds the reverse one. Very few basic researchers consider findings from the applied field relevant to their work (Critchfield, 2011). One way to mitigate this issue would be for basic researchers to focus on specific principles of behaviour that have practical relevance and can be used in either clinical or educational settings (Critchfield, 2011). However, such a solution would require that researchers are trained in experimental and applied behaviour analysis, or at least in some respect so they can confidently judge what research question would have meaningful and practical implications. This combination is relatively rare.

Another possibility is for basic and applied researchers to collaborate. However, Critchfield (2011) and Mace and Critchfield (2010) reported that applied colleagues invite their basic counterparts to collaborate more often than vice versa; hence, there is an opportunity to improve reciprocity for the betterment of science. Critchfield (2011) mentioned that one of the reasons why such collaborations are rare is because graduate programs are either basic or applied research-focused, producing experts in one or another area with little interest in the neighbouring side of behaviour analysis. Moreover, those raised in the Skinnerian tradition may still consider researching fundamental behaviour principles a priority despite more than 80 years of accumulated findings that serve as a relatively rich foundation for our discipline (Critchfield, 2011; Poling, 2010) and allow for the research focus to be shifted towards more practical problems. Despite these challenges, translational research is essential for the behaviour analysis field.

Mace and Critchfield (2010) reported successful collaboration of basic and applied researchers where laboratory relapse models were found useful to treat stereotypic behaviour in children with ASD or where the problem behaviour resumed, as predicted by the laboratory reinstatement model. Even if such cooperation is rare, it is the only way for behaviour analysis to thrive and be sustainable. The present dissertation is intended to achieve this goal by extending existing findings from basic studies to applied behaviour analysis.

1.5. The present dissertation

1.5.1. The aim

This dissertation aims at translating findings from basic research to applied studies. The findings in question suggest that the signalling properties of environmental events suffice to explain behaviour change, rendering unnecessary the proposed process of strengthening by reinforcement. To investigate how plausible it is to explain behaviour-environment interactions based on signals, I first review published applied studies and then conduct two experiments on clinically relevant behaviour (i.e. transitions) of neurotypical and neuroatypical children.

1.5.2. The research question

Accumulating basic research, primarily conducted with non-human animals, suggests that the signalling rather than strengthening properties of events explain the behaviour of organisms most plausibly. Can this supposition also improve our understanding of clinically relevant behaviour of children in applied studies?

2. Method

2.1. Paper 1: Stimulus Control in Applied Work with Children with Autism Spectrum Disorder from the Signalling and the Strengthening Perspective

Data collection methods and study aim

The study was a literature review which utilized online database (Medline using EBSCO and APA PsychInfo including PubMed using Ovind) searches conducted in July, August, and October 2021 to identify studies that met specific inclusion criteria described below. More thorough description is provided in the Appendix 1.

Experimental Design

The studies were included in the review based on specific inclusion criteria such as the specific aim of the study, the type of research design, the number and diagnosis of participants, the type of journal where the study was published and that findings reported resulted from the implemented interventions and were not incidental. To organize inclusion criteria, I used the PRISMA flowchart. More thorough description is provided in Appendix 1.

Strengths and Weaknesses

Among several strengths' worth mentioning, the study's main achievement is introducing signalling perspective to the applied behaviour analysts. Highlighting usefulness of this novel approach in which reinforcers are considered as signals that can fulfil a current disposition of an organism and guide it to where and how more of them can be obtained in the applied context is important, because it has been mainly discussed in conceptual (Cowie, 2020; Simon et al., 2020) and basic (Davison & Baum, 2006, 2010) papers. The wide scope of interventions reported in the articles included in the review, such as using video modelling to teach children with ASD social responses (Jones et al., 2014), or implementing bedtime fading routine to improve sleep in children with ASD (Delemere & Dounavi, 2018) showcase that signalling perspective can serve as a framework for applied experiments. Another strength of this study is that it fulfils the dissertation aim.

There are several limitations of the review including the limited number of papers discussed due to too stringent inclusion criteria. The review would have benefited from more detailed commentary of the results from strengthening and the signalling perspective. For example, a more detailed discussion on how signalling perspective was supported by the stimulus-control procedures and behaviour change would have been beneficial. In the signalling perspective stimulus control is reinforcer control, hence reinforcers both set an occasion for the behaviour to take place (by signalling access to future reinforcers) and can fulfil organism's current disposition. In all studies included in the review signalling properties of reinforcers were visible, for example in Jones et al., (2014) (explained in detail in Appendix 1), the presence of an adult signalled to the participants availability of the reinforcers based on their extended past experience of being exposed to interactions with adults during which reinforcers were available. These results could not be explained in such parsimonious way from the strengthening perspective, because the last reinforced response (interaction with either a peer or an adult) did not exert control of the upcoming response. More thorough description is provided in the Appendix 1.

Ethical Considerations

To ensure ethical considerations were met we included articles that were published in peer reviewed journals that require ethical approvals prior to conducting studies.

2.2. Paper 2: Control of Transition Time by the Likely Future as Signalled from the Past in Children with ASD

Participants, study setting, materials, and study aim

Four 5-year-old children with ASD diagnosis participated in the study. The study was conducted in the small treatment room at their kindergarten. The treatment room was equipped with three playmats arranged in a triangle, a chair for an observer and a Samsung tablet held by the experimenter. The aim of the study was to determine if not signalling the upcoming reinforcer context will shorten the transition time to the leaner reinforcer context, to examine if moderate reinforcer context can shorten the transition time to the signalled leaner

reinforcer context, and to explain the findings from the signalling perspective. More thorough description is provided in the Appendix 2.

Experimental design and data collection methods

An AB design was used in the study. It consisted of the Predictable Condition (A) and the Unpredictable Condition (B). In the Predictable Condition the upcoming reinforcer context was reliably signalled by the colour of the matt. In the Unpredictable Condition the colour of the matt did not reliably signal the upcoming reinforcer context. The duration of children's transitions between three playmats was measured by the TapTimer app by the main experimenter and by using pen and paper by the observer. The interobserver agreement and procedural fidelity were calculated. More thorough description is provided in the Appendix 2.

Strengths and Weaknesses

There are several strengths of the study worth mentioning. Firstly, the study aim was achieved, we observed that transition time between different reinforcer contexts can be reduced when the contexts are unsignalled. Secondly introducing moderate reinforcer context helps to reduce the transition time to the leaner reinforcer contexts when they are signalled. The signalling perspective accounts most straightforwardly for the findings because the behaviour was under the control of the upcoming reinforcer context which was especially visible in the Signalled Condition where the transitions to the leaner context were longer than those to the richer one.

The study has several limitations such as the research design used, and that no statistical analysis nor modelling was conducted. The AB design used in the study may have not sufficiently controlled for threats to internal validity. Moreover, due to the lack of replication of the experimental effect in an AB design, it is not possible to say with certainty whether any observed changes in the dependent variable are a reliable, replicable result of the manipulation of the independent variable. Nevertheless, the AB design provides preliminary objective data regarding the effects of an intervention when time and resources are limited (Kazdin, 2016). The findings would have been more conclusive if those limitations were addressed. More thorough description is provided in the Appendix 2.

Ethical Considerations

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. The study was conducted under Approval 282790 granted by the Regional Committee for Medical and Health Research Ethics, Approval 931299 granted by the National Center for Research Data and Approval RITM0140084 granted by the University Faculty Ethics Committee. Participation was voluntary and agreed upon with a signed consent form. Participants were informed that they can withdraw from the study at any point without any consequences. There were minimal psychological risks to the children associated with participation in the study. If any child got tired during the tasks they could rest at any time. We provided children with regular breaks during the testing to avoid tiredness. If any child became tired or found the research activities frustrating or discomforting, the activities would have stopped immediately without any consequences. The researcher had been trained to minimize any anxiety or distress to children by giving encouragement and maintaining a supportive and non-stressful environment. Every effort was made to make the participants comfortable and relaxed during the sessions.

2.3. Paper 3: Signalling Effects during Transitions in Children

Participants, study setting, and materials

Six 5-year-old neurotypical children participated in the study. The study was conducted in the small treatment room at their kindergarten. The treatment room was equipped with three playmats arranged in a triangle, a chair for an observer and a Samsung tablet held by the experimenter. The aim of the study was to determine if not signalling the upcoming reinforcer context will shorten the transition time to the leaner reinforcer context, to examine if moderate reinforcer context can shorten the transition time to the signalled leaner reinforcer context, to extend findings from Study 2 to neurotypical children, and to determine whether the findings can be explained from the signalling perspective. More thorough description is provided in the Appendix 3.

Experimental design and data collection methods

The reversal ABA design was used in the study. It consisted of the Predictable Condition (A) that was repeated and the Unpredictable Condition (B). In the Predictable Condition the upcoming reinforcer context was reliably signalled by the colour of the matt. In the Unpredictable Condition the colour of the matt did not reliably signal the upcoming reinforcer context. The duration of children's transitions between three playmats was measured by the TapTimer app by the main experimenter and by using pen and paper by the observer. The interobserver agreement and procedural fidelity were calculated. More thorough description is provided in the Appendix 2.

Strengths and Weaknesses

The study has several strengths. Firstly, we observed that transition time between different reinforcer contexts can be reduced when the contexts are unsignalled. Moreover, introducing moderate reinforcer context helps to reduce the transition time to the leaner reinforcer contexts when they are signalled. Those two findings replicated and extended results from Study 2 to neurotypical children. Lastly, the findings were successfully explained using the signalling perspective. The study has several limitations such as that no statistical analysis nor modelling was conducted. Statistical analysis may have allowed for the findings to be more conclusive and would allow to isolate the functional relations between the variables. Additionally, the differences in transition times among phases were only described based on mean values within and between participants. It would have been useful to use appropriate statistical methods (e.g., mixed-effects modelling) to validate obtained results further. Furthermore, including children that prefer activities other than videos might have made the study more interesting. More thorough description is provided in the Appendix 3.

Ethical Considerations

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. The study was conducted under Approval 282790 granted by the Regional Committee for Medical and Health Research Ethics, Approval 931299 granted by the National Center for Research Data and Approval RITM01945551 granted by the

University Faculty Ethics Committee. Participation was voluntary and agreed upon with a sign consent form. Participants were informed that they can withdraw from the study at any point without any consequences. There were minimal psychological risks to the children associated with participation in the study. If any child got tired during the tasks they could rest at any time. We provided children with regular breaks during the testing to avoid tiredness. If any child become tired or found the research activities frustrating or discomforting, the activities would have stopped immediately without any consequences. The researcher had been trained to minimize any anxiety or distress to children by giving encouragement and maintaining a supportive and non-stressful environment. Every effort was made to make the participants comfortable and relaxed during the sessions.

3. Summary of papers in this dissertation

3.1. Paper 1: Stimulus Control in Applied Work with Children with Autism Spectrum Disorder from the Signalling and the Strengthening Perspective

Study 1 sets the scene for the two experiments and proposes that the signalling perspective offers a more straightforward explanation of behaviour modification interventions in children with Autism. The paper provides a comprehensive review of five studies that used stimulus control ABA techniques to broaden the repertoire of socially significant behaviour or to reduce the problem behaviour in children with Autism. Most ABA interventions are based on the Skinnerian understanding of behaviour (elaborated on in the introduction of this dissertation), which served the field well; however, with the growing research on the signalling perspective, it is advantageous to explore them from a different angle.

Hence, this review aimed to determine whether the behaviour change reported in these applied studies can be explained by (recent) past events or by likely future events based on extended past experience. The former concept is associated with the notion of Skinnerian response strength, while the latter view involves identifying extended environmental patterns that signal which behaviours are likely to be reinforced. Each study's findings were examined separately from the signalling and strengthening perspectives. The results indicated that the signalling perspective offers a more comprehensive understanding of behaviour modification interventions for children with ASD.

The implications for future research in this area were also discussed, such as the need to design interventions with the signalling perspective as a theoretical background to improve effectiveness and theoretical consistency, which is what we did in Studies 2 and 3.

3.2. Paper 2: Control of Transition Time by the Likely Future as Signalled from the Past in Children with ASD

Study 2 addressed the need to design an applied study with the signalling perspective as a theoretical background mentioned in Study 1. We replicated and extended the study of Jessel et al. (2016) and examined transitions between activities in children with Autism. Unlike the original study, our focus was not on problem behaviour associated with transitions; instead, we aimed to learn what mechanisms drive behaviour during transitions. Thus, we aimed to determine whether the transition times from one reinforcer context to another are controlled by the most recent past or the likely future based on more extended past experience. During the experiment, children travelled between three different playmats, each associated with a different reinforcer context (green mat represented rich context, yellow represented moderate context, and blue represented lean context). Upon arriving at the playmat, children watched videos whose lengths represented the context (the 30s in a rich context, 10s in a moderate context and 5s in a lean context). In the first condition, the colour of the playmat reliably corresponded with the reinforcer context. We observed that the transitions to the leaner context were longer than those to the richer context. In the second, unsignalled condition, those differences disappeared, and the lengths of the transitions between contexts were more similar, which was in line with Jessel et al.'s (2016) findings. This suggests that behaviour is primarily controlled by signals of likely future reinforcers as extrapolated from extended past experience rather than strengthened by the most recent event. If the transitions from a rich to a leaner context in the first condition were shorter instead of longer, the strengthening perspective would have been a reasonable explanation, but this did not take place.

Those findings extend the current research on the signalling perspective and serve as an example of useful clinical application of this view. The results also enabled us to fulfil the aim of this dissertation to translate the basic findings to a broader applied setting.

3.3. Paper 3: Signalling Effects during Transitions in Children

The aim of Study 3 was to extend the findings from Study 2 and to investigate if the same phenomenon can be observed in neurotypical children. As in Study 2, we examined transitions between activities to discover which mechanisms drive

the behaviour during transitions. In this study, we used a reversal design and introduced two phases of the predictable condition to validate the findings further. Otherwise, the procedure was identical to Study 2, where children walked between three different playmats representing three reinforcer contexts (rich, moderate, and lean).

Findings from this translational study support existing evidence that the signalling perspective is a more plausible explanation of behaviour during transitions between activities. The transition times from a rich to a leaner reinforcer context were longer than the opposite ones in both predictable conditions. The strengthening perspective cannot account for those findings as the just obtained reinforcers did not determine the length of the following transition. Instead, it was determined by the upcoming reinforcers, resulting in a shorter transition time to the richer than the leaner contexts. Obtained results are particularly useful and informative for applied behaviour analysts because they further confirmed that not signalling the upcoming context can reduce the transition time to leaner reinforcer contexts. Moreover, adding a moderate reinforcer context can reduce the transition length from a richer to a leaner context by half, even when signalled. Moderate context can be useful for basic and applied researchers when designing procedures where transitions to the leaner context are signalled and unavoidable.

Since Study 2 and Study 3 used the same methodology and incorporated strict fidelity measures, they serve as an example of translational research that allows reliable further basic and applied replications.

4. Conclusion

4.1. General Discussion

The goal of this dissertation was to provide additional insight into the understanding of the signalling perspective, especially in the applied context. I aimed to achieve it by conducting a review of existing applied studies from a signalling and strengthening perspective and by conducting two applied studies on clinically relevant procedure in neurotypical and neuroatypical populations using signalling perspective as a theoretical background. The applied studies also aimed to translate basic results suggesting signalling perspective's usefulness in explaining behaviour-environment relations.

In Study 1, the signalling perspective provided a more straightforward and plausible explanation of stimulus control-based ABA interventions in children with ASD. In signalling perspective, stimulus control is reinforcer control. Reinforcers serve as an environmental signals that signal to the organisms where and how more of them can be obtained. In signalling perspective reinforcers set an occasion for the behaviour to take place, but they also fulfil organism's current disposition. This was especially noticeable in studies aiming to teach participants new skills by establishing reinforcer control (Borgen et al., 2017; Delemere & Dounavi, 2018; Ingvarsson et al., 2016). Even though each study investigated different procedure in each of them reinforcer's signalling function was predominantly responsible for the skill acquisition. For example, in Ingvarsson et al., (2016), a question asked by a therapist signalled to a participant possible future reinforcers should a correct answer be provided. The mastery criterion was based on correctly answering several questions in a row. The strengthening properties of reinforcers did not play a role in this process because the observed behaviour change was not perpetuated by the just reinforced response, but rather by extended past experience in which reinforcers signalled availability of future reinforcers for correct answers. Those findings extended previous findings reporting usefulness of the signalling perspective (Cowie, 2020; Davison & Baum, 2006, 2010).

Motivated by those results, Study 2 and Study 3 were designed to test the applicability of the signalling perspective in explaining behaviour during transitions between activities in children with ASD and neurotypical children.

Findings from both studies confirmed that the signalling perspective offers a more straightforward explanation of observed behaviour because the upcoming reinforcer context determined the length of the transitions in the predictable conditions. The colour of the mat reliably signalled the upcoming reinforcer context in the signalled conditions and hence the transition times to the richer context were shorter than those to the leaner one. This finding was observed in both populations. In Studies 2 and 3 transitions were arranged only between different reinforcer contexts (i.e. rich-moderate, lean-moderate, moderate-rich, lean-rich, moderate-lean and rich-lean) and not between the same ones (i.e. lean-lean, moderate-moderate, or rich-rich) hence the signalling properties of the upcoming reinforcer context were more noticeable since they always signalled either betterment or worsening of the upcoming conditions compared with the previous one. Such experimental design allowed to highlight the signalling properties of reinforcers, but also to test a procedure that has not been researched before. Moreover, the reinforcer context children were walking from did not affect the transition length either in Study 2 or in Study 3, which makes the results challenging to explain from the strengthening view. Additionally, both studies showed that introducing a moderate reinforcer context can significantly reduce the transition length to the leaner reinforcer context when it is signalled and unavoidable. This finding has practical implications; it can help individuals who struggle with transitions. In the natural world, organisms experience a vast range of transitions that greatly exceed the dichotomic lean and rich categories. Hence, introducing a moderate context extended the usefulness of the results.

Furthermore, together with the existing research on transitions, our results provide additional evidence that unsignalled transitions to a less favourable context are more effective interventions than advance notice procedures (Jessel et al., 2016; Langford et al., 2019; Toegel & Perone, 2022) to reduce time spent transitioning, which is especially useful for the applied field.

When transitions were unsignalled, the difference between transition times to either rich, moderate, or lean context disappeared in children with ASD and neurotypical children. This finding aligns with the results from basic studies (Toegel & Perone, 2022) and applied ones (Jessel et al., 2016). Moreover, results from Study 3 extended the generality of those findings to neurotypical children, a population that has not been studied before with this procedure. As mentioned in Study 3, this is an important finding because it informs practitioners that

arranging transitions between different reinforcer contexts in an unsignalled manner is more effective than the advanced notice procedure(Brewer et al., 2014; Toegel & Perone, 2022). One of the aims of Study 3 was to provide additional evidence that can encourage practitioners to incorporate unsignalled transitions into the activity schedules and improve children's ability to transition successfully between different tasks.

Despite the encouraging results from Study 2 and Study 3, it is worth considering some aspects before introducing unsignalled transitions. Similarly, before introducing any other treatment option, a functional assessment should be conducted to determine what maintains problem behaviour during transitions before deciding to include unsignalled transitions in a treatment plan. If problem behaviour is maintained by the uncertainty of the upcoming activity, introducing unsignalled transitions will not be a suitable treatment option, and other procedures that provide signals signalling the upcoming activity would be more effective. In such situations, as the results from Studies 2 and 3 suggested, introducing a moderate context to broaden the array of upcoming reinforcer contexts can be helpful. However, other interventions, including unsignalled transitions, may prove useful if the unpredictability does not induce problem behaviour. Thus, it is not conservative to suggest that unsignalled transitions have the potential to help in certain situations. However, similarly to other treatment options, there are limitations that should be considered before implementation.

Several possible explanations for why the signalling perspective is an alternative to the strengthening view, which is worth considering, have been provided in the discussion sections in each article included in this dissertation. One implication of these findings is that the role of behaviour and environment interactions should be conceptualised within the broader context, such as genetic history, learning history, current motivation, and the availability of alternative sources and types of reinforcers (Cowie, 2020; Shahan, 2017).

However, a long line of research such as the behaviour momentum theory (BMT) suggests that the Skinnerian concept of strength can be measurable (Nevin, 2012; Nevin & Grace, 2000; Nevin & Shahan, 2011). Behaviour momentum theory quantifies response strength by measuring behaviour's response rate and resistance to disruption (Nevin & Grace, 2000). The reinforcer rate refers to the

frequency and predictability of positive outcomes following a behaviour. At the same time, resistance to change reflects the tendency of behaviour to persist despite environmental changes (Nevin & Grace, 2000). This resistance can be influenced by factors such as the history of reinforcement, the reinforcement schedule, and the behaviour's strength. The BMT suggests that behaviours with a higher response rate and those that have been consistently reinforced are more resistant to disruption or extinction.

However, a growing number of studies have shown that measures such as preference and resistance to change, considered indicators of response strength, do not necessarily correlate, as claimed by Nevin & Grace, (2000), as cited in Bell & Baum, (2021). They suggested that resistance to extinction could not explain the response strength concept because the foundation of behavioural momentum theory was built on extensively training baseline discrimination while neglecting training on food/no-food discrimination (Bell & Baum, 2021).

Numerous examples throughout this dissertation illustrate a main challenge with the notion of response strength: it appears to hinder behavioural research rather than assist it (Cowie, 2020; Shahan, 2017; Simon et al., 2020). The challenge with the Skinnerian concept of response strength lies in its numerous possible meanings. The absence of consensus regarding a standard measure of strength (for example, the BMT) creates difficulties for researchers attempting to determine the most effective means of altering behaviour. Without a shared understanding of what the response strength concept entails, we may end up building science around a process that is “not reducible to the observable” (Cowie, 2020, p.351). This could be viewed as approaching the realm of hypothetical constructs discussed by Killeen & Hall, (2001)(discussed at length in the introduction).

When we shift our focus away from the Skinnerian response strength, we recognise that the differences between different operant, respondent, adjunctive, and instinctive behaviour map onto variations in environmental structure rather than underlying mechanisms. Consequently, how parameters such as environmental structure, phylogeny, affordances, and organismic dispositions that generally control behaviour influence the extent and division of control by different signals could be a focus of behaviour analysis (Cowie, 2020).

Notably, while the research mentioned in this dissertation indicates the advantages of the signalling perspective compared to the Skinnerian concept of strength, the choice between these two paradigms cannot be based on empirical observations but on the satisfactory interpretation of such data. The strengths of the signalling view lie in its capacity to incorporate experimental findings, its support for quantitative theories, and its relevance to everyday situations (Baum, 2002). A plethora of studies (Baum, 2020, 2021; Cowie et al., 2011, 2021; Cowie & Davison, 2020; Davison & Baum, 2006, 2010) suggests that the signalling perspective can be an alternative worth considering in explaining organism-environment relation.

4.2. Translational relevance

The importance of translational research in behaviour analysis has been mentioned throughout this dissertation and in the behaviour analysis literature (Critchfield, 2011; Kyonka & Subramaniam, 2018; Mace & Critchfield, 2010). The limited number of such studies (Critchfield, 2011) is due to many factors, such as narrow graduate training and, hence, lack of competence in conducting research in either basic or applied fields. The easiest solution for this issue is collaborating with other researchers, but even that is uncommon (Critchfield, 2011).

The studies in this dissertation add to the current literature on the treatment of problem behaviour during transitions in different populations and the usefulness of the signalling perspective as a theoretical background for applied studies. This dissertation attempts to bridge the gap between existing basic and applied literature by building on findings in human and nonhuman operant laboratory experiments, extending them to different populations, and introducing new variables (moderate reinforcer context during transitions) that have not been studied.

4.3. Further applied research

The findings from the present series of experiments have many implications for the applied field. One possible future line of research would be studying

transitions between activities in more naturalistic settings, such as during Early Intensive Behavioural Intervention (EIBI) activities for children with ASD or daily activities in kindergarten for neurotypical children. Conducting research in children's natural environment in which problem behaviour occurs would inform us whether the elements of functional relations demonstrated in our studies exist outside the experiment under naturally occurring conditions, free from prearranged contingencies. However, strict procedural fidelity measures would be required to avoid the typical limitations of such studies (Toegel & Perone, 2022). Also, since transitions between activities are not limited to preschoolers (Sterling-Turner & Jordan, 2007), extending findings to older children would help to generalise the outcomes and provide the basis for evidence-based interventions for the broader populations.

4.4. Final remarks

Although the signalling perspective has been studied for many years, it was under-investigated in applied behaviour analysis (see Wood & Simon, 2023 for a brief discussion). In contrast, much research has closely examined the signalling perspective in basic experiments with non-human participants (Cowie et al., 2011; Davison & Baum, 2006; Shahan, 2010) or in theoretical papers (Cowie, 2020; Shahan, 2017; Simon et al., 2020).

What is needed is similarly thorough research examining the signalling perspective in applied experiments with human participants. Closely examining the complexities of reinforcers' signalling properties will enable us to explain better, predict more accurately, and modify behaviour in the natural world more efficiently and effectively. This dissertation is a step towards this goal.

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Appendices

Paper 1: Stimulus Control in Applied Work with Children with Autism Spectrum Disorder from the Signalling and the Strengthening Perspective

Wood, A., & Simon, C. (2021). *Norsk Tidsskrift for Atferdsanalyse*, 48, 279 - 293

Paper 2: Control or Transition Times in Children with ASD from a Signalling/ Strengthening Perspective

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Paper 3: Signalling Effects of Reinforcers during Transitions in Children

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Paper 1

Stimulus Control in Applied Work with Children with Autism Spectrum Disorder from the Signalling and the Strengthening Perspective

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Experimentally and theoretically oriented behaviour analysts have predominantly debated the usefulness of the 'response strength' concept. We analysed applied studies to open the discussion on the usefulness of 'response strength' versus an alternative view on understanding how the past controls current behaviour in applied contexts. This review examined five studies that focused on evaluating an intervention using stimulus control Applied Behaviour Analysis (ABA)-based techniques to teach skills to children with Autism Spectrum Disorder (ASD). The review aims to understand if behaviour change in applied studies is most straightforwardly understood as driven by the most recent past events or by likely future events extrapolated from more extended past patterns of events. The former is the basis of the concept of response strength. In the latter view, behaviour is exhaustively accounted for by identifying an extended pattern of events in the environment, which signals to the organism which behaviour will most likely produce a reinforcer. The findings of each study are analysed separately from both the signalling and the strengthening perspective. The results suggest that the signalling view provides a more comprehensive understanding of behaviour modification interventions in children with ASD. Implications for future research are also discussed.

Key words: Stimulus control, ASD, response strengthening, signalling

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Individuals with Autism Spectrum Disorder (ASD) receive several therapeutic interventions that can significantly improve the quality of their lives. Among those, interventions based on Applied Behaviour Analysis (ABA) are commonly used and recommended by the American Academy of Paediatrics and the National Research Council (Hyman et al., 2020). An example of such intervention is teaching children socially significant behaviour or working on decreasing problem behaviour.

A significant number of studies, including long-term, large-scale ones, confirmed that children who receive over 25 hours of ABA therapy weekly for more than one year achieved a tremendous increase in their skills, with some children matching the developmental goals for their age (Eikeseth, 2009). The effectiveness of ABA techniques in interventions for children with ASD was validated in a meta-analysis (Virués-Ortega, 2010). It states that long term ABA interventions lead to "medium to large terms of intellectual functioning, language develop-

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ment, acquisition of daily living skills and social functioning in children with autism." (Virués-Ortega, 2010, p. 387).

The success of ABA interventions lies in establishing stimulus control. A stimulus serves as a cue signalling which behaviour needs to follow to produce a reinforcer. In this view, stimulus control is established when a child reliably discriminates, which response will lead to a currently significant event (a reinforcer). Virtually all behaviour analysts agree that behaviour depends on its ontogenetic and phylogenetic past. Our main task is to account for the ontogenetic past, that is, the learning history. Traditionally, most behaviour analysts agree implicitly that the past contributes to our current behaviour because the consequences of our past behaviour determine the strength of our current behaviour. Several behaviours of an organism's repertoire compete until the strongest behaviour wins and becomes observable. Palmer (2009) made this view explicit. This approach has served us well. However, at times it fails to explain the behaviour we are observing. On fixed-interval schedules, for example, the behaviour disappears right after the reinforcer is presented. This pattern is difficult to explain if reinforcers occurring contiguously with responses are assumed to produce the strongest behaviour. Another common observation is the reinstatement of extinguished behaviour happening when an event that used to function as a reinforcer for that behaviour is presented non-contingently, leading to what is commonly viewed as immediate restoration of behavioural strength. This phenomenon can be challenging in the case of an applied intervention aimed at discontinuing problem behaviour. Based on these observations, experimental and theoretical behaviour analysts have introduced a different perspective on understanding how our past contributes to our current behaviour. In this article, we will refer to it as the 'signalling perspective'.

In the signalling perspective, reinforcers on fixed-interval schedules are assumed to signal the organism to consume the reinforcer and not respond for a specific interval. When behaviour is reinstated due to what used to function as a reinforcer, this presentation is assumed to signal to the organism that reinforcers are available again. Accounting for these phenomena faces fewer problems from the signalling view than the strengthening view because we do not have to identity behaviour contiguous with reinforcers. In the signalling view, stimulus control is reinforcer control, whereby the concept of response strength become superfluous, which is a good thing considering the problems with this concept, which are elaborated upon, for example, in Cowie et al. (2019), Shahan (2017), and Simon et al. (2020).

Considering the nature of ASD, clinicians have to account for several issues, such as the difficulty to establish stimulus control (Borgen et al., 2017; Ingvarsson, 2016) that can take precedence during the intervention.

In the signalling view, changes in behaviour happen according to what is likely to occur next, as generalised from often extended past experience. Consequently, the behaviour comes under the control of correlations of events in the environment. The effect of the current significant event on behaviour depends predominantly on one's likely future as generalised from past experience and the current situation (Cowie, 2018). In the following, we will illustrate the signalling view with the help of an applied study by Jessel et al. (2016) and a basic scientific study by Krägeloh et al. (2005).

Jessel et al. (2016) examined transitions between different contexts (rich-rich, lean-lean, rich-lean, and lean-rich) in children with ASD. Not surprisingly, they observed that the transition to a lean context took the children significantly longer than the transition to a rich one. This phenomenon was observed in the first part of the study. The colour of the playmat the children were transitioning to matched the specific reinforcer density (green and yellow mats signalled rich reinforcement and blue and

red signalled lean reinforcement). For example, when asked to transition to the green mat, they would always have access to their preferred toy. When they were asked to transition to the blue mat, only the less preferred toy was available. In the second condition, the upcoming reinforcer density was unsignalled. This removed the differences in transition time. In that condition, the colours of the mats were not contingent upon the availability of certain toys as in the first condition, which removed predictability, i.e., the likely future could no longer be predicted from the past[1]. The colour of the playing mat would not affect the availability of preferred or less preferred toys. Consequently, when transitioning to a specific mat, the child could not know what toys would be available until they transitioned and the toy was presented to them.

These findings suggest that the availability of discriminative stimuli signalling the density of reinforcement waiting after the transition was responsible for the duration of transition and problem behaviour that accompanied it during shifts to the lean context. It was the likely future (toy they were going to as signalled by the mat colour) and not the immediate past (toy they were coming from) that controlled their behaviour (dawdling) when discriminative stimuli/signals(mat colours) were available. This difference in transition time disappeared when nothing was indicating events in the near future. This experiment illustrates that behaviour is controlled by what the next significant event (reinforcer) is likely to be, and not what behaviour has just been strengthened (i.e., if they had just played with the preferred toy or not). The central question is how extended the stimulus/reinforcement pattern in the environment is that controls behaviour. The strengthening view focuses on behaviour occurring directly before the reinforcer, while the signalling view focuses on more extended behaviour patterns and reinforcers.

In Krägeloh et al. (2005), pigeons were presented with two keys producing food pellets. Food was presented contingent on a pigeon having pecked on the other key most recently, i.e., it was contingent on switching pecking location. If the most recent behaviour had been strengthened, the pigeons would have pecked in the exact location again; however, the (more extended) pattern of availability of food contingent on not having been available in that location on the recent peck signalled the pigeons where food would be available next. Quickly learning this behavioural switching pattern makes sense from a phylogenetic perspective when organisms consume resources that deplete in a specific location after one act of consumption. Having consumed the resource will then signal that a switch of location will generate more of that resource, not staying where the behaviour was successful (i.e., reinforced).

In the following, we review five studies that evaluate an intervention using stimulus control ABA-based techniques to teach skills to children with ASD. We discuss their intervention effects from the signalling and the strengthening perspective.

Method

Literature search

The search was conducted in July, August, and October 2021 using the following online databases: Medline using EBSCO host and APA PsycInfo (including PubMed) using Ovid.

In each database, searches were conducted by inputting a search term related to diagnosis (i.e., *autism* or *ASD*) combined with *stimulus control* and *children* to form the following search query).

[1]Note that when we say "predicted", "extrapolated", "know", "experienced", and the like, we do not mean to imply that the organism engages in any activities in addition to its overt behaviour that we aim at explaining. The prediction, for example, *is* the behavior under stimulus control. Throughout this paper, "to predict the future from past experience" means solely that the organism's current behaviour is under control of past experiences and when the patterns in the environment in the past match those in the future, that behaviour will produce significant events ("reinforcers").

All abstracts returned during the electronic searches were reviewed to determine their suitability for inclusion.

Study Inclusion Criteria

The principal investigator screened titles and abstracts of the database searches and retrieved articles to determine eligibility. See Figure 1 for inclusion criteria.

Studies were included in this review based on the following criteria: each study (1) was an evaluation of intervention using stimulus control to teach a skill (2) implemented multiple baseline design across participants

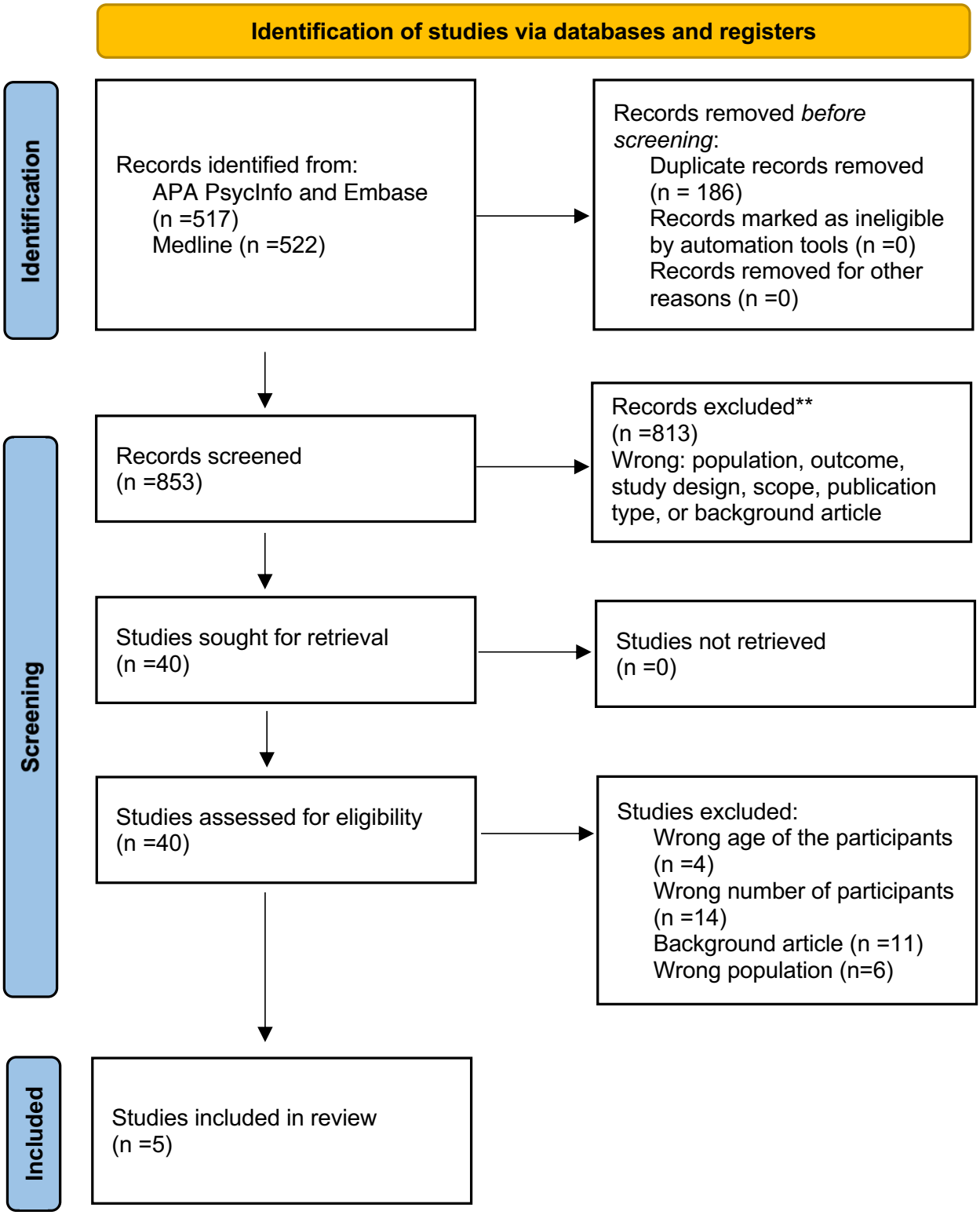

Figure 1. PRISMA 2020 Flowchart of the Study Selection Process.

(this design is particularly recommended to demonstrate that a significant behaviour change occurred as a result of the intervention, Hawinks et al., 2007), (3) had at least four participants aged 2-10 years old diagnosed with ASD (4) utilised observation to report data and (5) was reported in a peer-reviewed English language journal.

Studies were excluded when they described interventions that were not ABA-based or where the participants had additional diagnoses such as Attention Deficit Hyperactivity Disorder (ADHD) and other mental health disorders, and their data could not be disaggregated. For this review, we used the following definition of ABA techniques: ABA techniques are based on the "principles of behavior and are applied systematically to improve socially significant behavior, and experimentation is used to identify the variables responsible for behavior change" (Cooper et al., 2014 p. 2). Other criteria that disqualified research papers were when studies had isolated outcomes or the intensity/ duration standards of the intervention were not met. Additionally, articles that reported anecdotal records, monographs, master's theses, and literature reviews were excluded. All documents are available for others to crosscheck by contacting the first author. Data were collected on each study using a structured data sheet that included the reference: sampling size, age, gender, and diagnosis of included participants, setting, type of implementer, intervention type, experimental design, and whether measures of generalisation or maintenance were collected and the results of those conditions. Results of the studies were classified as positive, negative, or mixed based on the authors' determination.

Positive effects were noted when the authors indicated that the procedure was effective for all included participants. Negative results would have been shown if the authors stated that the intervention did not affect any of the participants included in the study. Mixed results would have been noted if the authors pointed out that the intervention was effective for some participants. No studies reported results from interventions that were disadvantageous for the participants.

Results

Table 1 provides an overview of data collected to evaluate interventions using stimulus control ABA-based techniques to teach a skill to children with ASD. Five studies met the inclusion criteria.

General Findings

The findings from this literature review are presented in Table 1. The current review studies included 22 total participants ranging in age from 2 to 8 years, all diagnosed with ASD. Classrooms in different settings (Day centre, Elementary Public School, Centre for children with developmental disabilities and Early intervention centre) were the context for intervention in 90% of the studies and researchers' office and home of the participant compromised of 10% of the studies. Therapists were the interventionists in three of the studies, followed by teachers in one research and researchers' and parents in the remaining study. Maintenance of treatment gains was not documented in any studies; however, generalisation measures were collected in 80% of the studies. Positive effects of the intervention were reported in 90% of the studies. Each paper reported different interventions, but all of them utilised stimulus control ABA-based techniques. Communication skills were targeted for intervention in 60% of the included studies; however, each focused on a different aspect. Ward et al. (2019) explored mand training using stimulus control procedure to encourage "acquisition and generalisation of mands for specific activities" induced by motivating operations (Ward et al. 2019, p. 215). Jones et al. (2014) surveyed social responses and generalisation in children with ASD when the recipients were either adults

Table 1. A Brief Overview of the Selected Studies.

Reference	Sample size	Age	Gender	Diagnosis	Setting	Type of implementer	Intervention type	Experimental type	Generalisation	Maintenance	Results
Borgen et al. (2017)	4	2 -3	1 F 3 M	ASD	Early Intervention program classroom	Therapists	Compliance with instructions by initiating the requested behaviour	Multiple baseline design across participants for Lucy and Patty with a brief return to baseline. Mixed schedule design with two different therapists for Charlie. ABAB design for Linus with a different therapist implements each baseline and treatment phase, followed by a please without reinforcement to comply with low-p instructions.	Stimuli but only for 2 participants	No	Positive

Table 1. Continued.

Reference	Sample size	Age	Gender	Diagnosis	Setting	Type of implementer	Intervention type	Experimental type	Generalisation	Maintenance	Results
Delemere et al. (2017)	6	2-7	1 F 5 M	ASD	Researchers' office and participant's homes	Researchers and parents	Bedtime fading and positive routines	Concurrent multiple baseline across subjects' designs were used to evaluate three independent variables on bedtime fading and positive routines.	No	No	Positive for bedtime fading and mixed for positive routines
Ingvarsson et al. (2016)	4	6-8	0 F 4 M	ASD	Center for children with developmental disabilities classroom	Therapists	Blocked trial procedure to establish complex stimulus control over intraverbal responses	Concurrent multiple probe design across question pairs was utilised to measure the effect of the blocked trial procedure on discriminated intraverbal responding.	No	No	Positive

Table 1. Continued.

Table 1. Continued.

Reference	Sample size	Age	Gender	Diagnosis	Setting	Type of implementer	Intervention type	Experimental type	Generalisation	Maintenance	Results
Jones et al. (2014)	4	4-6	2 F 2 M	ASD	Day centre classroom	Therapists	Emitting target response during the activity	Concurrent multiple baseline design across participants was used to evaluate the effects of independent variables on the acquisition and generalisation of the targeted social responses.	Setting	No	Positive
Ward et al. (2019)	4	5-7	2 F 2 M	ASD	Elementary Public-School classroom	Teacher	Discrete trial training on a variety of verbal operant	Concurrent multiple baseline design across participants.	Setting	No	Positive

Note. F= female, M=male

or peers. Ingvarsson et al. (2016) studied the effectiveness of the blocked-trials procedure to establish complex stimulus control over intraverbal responses in children with ASD. Borgen et al. (2017) aimed to evaluate a procedure to establish compliance with instructions in children with ASD. Delemere et al. (2018) focused on positive routines and bedtime fading for sleep disorders in children with ASD.

Signalling versus Strengthening in the Studies

Three studies addressed establishing stimulus control in children with ASD. The first study (Ingvarsson et al., 2016) used a blocked trials procedure). The second study discussed establishing a novel therapist as a source of positive reinforcement (Borgen et al., 2017). The third utilised two procedures to increase appropriate sleep behaviours (Delemere et al., 2018).

Blocked-trials procedure to establish Complex Stimulus Control over Interverbal Responses in Children with Autism

According to Ingvarsson et al. (2016), the blocked-trial procedure effectively establishes stimulus control in children with ASD and increases intraverbal behaviour. In this procedure, participants were presented with a stimulus in separate trial blocks. The blocked trial procedure includes presenting sample stimuli in alternating blocks of trials. The size of the trial blocks is gradually reduced contingent upon correct responses until the order of presented stimuli is random. All of the participants mastered intraverbal discrimination using this procedure; however, some additional modification in the procedure was required for two participants. The order of the intraverbal probes was explicitly designed to enable researchers to assess the potential control exerted by multiple elements of the prior verbal stimuli.

Among several possible explanations why the blocked trials procedure yielded discriminated performance and increased participants' intraverbal behaviour is that repeated presentation of the auditory stimuli (a question asked by interventionists) can increase stimulus control (Ingvarsson et al. 2016).

When considering this phenomenon from the signalling perspective, which views behaviour as a pattern of activities extended in time (Baum, 2002), one can suggest that the success of this intervention relies on the reliability of verbal cues. In Ingvarsson's study (2016), a question asked by an interventionist (a verbal cue) signalled possible events in the near future, such as progression to the next step if the correct answers were provided. Hence, providing answers can be viewed as "extended behavioral allocations or activities" (Baum, 2002, p. 95). According to Baum (2002), a discriminative stimulus indicates that one activity offers more frequent reinforcement than another and increases the time one spends engaging in that activity. The same event can serve both as a discriminative stimulus and a reinforcer.

The results presented in this study add to the existing research, which suggests that behaviour depends on likely future reinforcers as generalised from past experience. Behaviour is driven by the prediction of the likely near future that allows the organism to fulfil the current dispositions based on its more extended history (Cowie, 2018). In Ingvarsson et al.'s (2016) study, we could observe this when participants' correct discrimination was based on their learning history with successfully established discriminative stimuli (a question asked by the interventionist) that signalled possible future reinforcers (descriptive praise offered by the interventionist after providing the correct answer).

From a perspective of strengthening, the results of this study (successful acquisition of multiple discriminations) would imply that the reinforcement provided for the last response (participants' last answer) resulted in the mastering of the particular discriminative skill. Ingvarsson et al. (2016) defined the mastery criterion as a child providing ten consecutive correct answers within

two sessions. Furthermore, we can observe that the overall pattern of responding (ten consecutive answers) enabled discrimination skill acquisition. Discriminative stimuli are viewed as events modifying the probability of a response. In this study, we consider them the context that sets an occasion for a response to occur. Verbal cues (questions asked) provided by the interventionist induced a response from the participant (an answer to a question asked). Participants' choice (providing an answer) was based on their extended past experience and discriminative stimulus (a question asked by an interventionist) available in the current situation.

A Method to Establish Stimulus Control and Compliance with Instructions

According to Borgen et al. (2017), a stimulus that had no previous history of exerting control over a particular (compliant) behaviour can gain the capacity to reliably prompt a response specified in an instruction. As Borgen et al. put it, for stimulus control to be successfully developed is for a "reinforceable response to reliably follow the presentation of the stimulus" (p. 831). It is also necessary that the probability of the reinforcers is higher in the presence of the stimulus than in its absence. The study aimed to evaluate a procedure to establish compliance with instructions in children with ASD.

Borgen et al.'s (2017) study consisted of three phases. The first phase was a baseline where the low probability of compliance instructions was delivered to the child at a minimum of 1-min intervals. Compliance with the instructions was reinforced, and non-compliance was ignored. It was followed by the compliance procedure to establish stimulus control, which consisted of ten steps followed in the same sequence across the participants. The researchers assumed that establishing stimulus control would be the easiest if the novel therapist was introduced since children would not have a history of non-compliance. The reinforcers were identified through preference assessment and were initially given to children on variable time 60s schedule, which continued for 6–8 minutes. Afterwards, an orienting cue was delivered when a child stopped the activity for 2–3 seconds. The cue was presented by saying a child's name in a very candid way that was novel and aimed at increasing the likelihood of orientation to the novel sound. Depending on an orienting response, the therapist handed over a piece of food (which served both as a discriminative stimulus and a reinforcer for compliant behaviour) from an approximately one-meter distance. When a child was approaching, they delivered the instruction to take it. The purpose of that procedure was to establish stimulus control of compliance with instructions. When correct responding to the instructions with a high probability of compliance was achieved (reliably responding to the name and taking food from a novel therapist), the researchers introduced low probability instructions, which consisted of higher demands and a leaner reinforcement schedule. The final phase was the parent training. The compliance scores in the baseline condition were low for all participants (below 20%); however, when a novel therapist was introduced in the treatment condition, scores were substantially improved (between 80%–95%), which suggested that when stimulus control was successfully developed (with the SD being a novel therapist delivering an instruction), participants produced a correct response based on their past experience (learning history with a novel therapist) and predicted events in the near future that instructions delivered by a novel therapist had signalled.

Addressing findings of this study from the strengthening perspective means to view behaviour as a result of reinforcement of the most recent response. However, the results reported by Borgen et al. (2017) suggest that the behaviour change occurred primarily due to the successful establishment of stimulus control, which was signalled by reliable orienting cues. Reinforcers did not strengthen the previous discrete response; instead, they

induced the pattern of behaviour (participants responded correctly to 3–8 high probability instructions and, thus, moved to the next phase of the study) that can be repeated in the future. Before introducing the low probability of compliance instructions (which were presented consecutively and the responding was scored as an overall pattern of responding to the sequence, not per response), researchers ensured that participants had an established experience of the high probability of compliance instructions. Hence, stimulus control over cooperative behaviour was instituted.

Parent Implemented Bedtime Fading and Positive Routines for Children with Autism Spectrum Disorder

Delemere et al.'s (2017) article explores two stimulus control-based interventions on total sleep duration, sleep onset latency and duration of night awakenings in children with ASD. It contained two settings. First, the participants' parents attended a brief training at the researcher's office, followed by parent-led intervention at participants' homes. Parents were asked to observe and measure their children's sleep behaviour each day and collect data using the sleep diary, both in the conditions of positive bedtime routines and bedtime fading. Positive bedtime routines consisted of a set of enjoyable and calming activities completed in a specific order to facilitate the sleep onset. Completion of each activity is praised, and transition to the next one commences. Routines move from rich to lean reinforcement, to establish appropriate sleep onset SDs by establishing behavioural chain terminating in behavioural quietude. Delemere et al. 2017 regarded sleep onset as the final reinforcer for completing this chain. Bedtime fading's central aim is to manipulate the sleep-wake cycle to increase the rapid sleep likelihood. The intervention requires temporarily moving bedtime to coincide with the child's natural sleep onset more closely. It allows immediate sleep initiation and then fading the intervention earlier if sleep onset latency remains short according to the developmental norms and parents' habits (Delemere et al., 2017). Before the intervention, the functional assessment interview was conducted to measure any environmental aspects contributing to sleep problems. The study was divided into a few phases, pre-baseline consisting of the meeting with the researcher and discussing the investigation. It was followed by the baseline phase, during which parents were asked to collect data on the current sleep routines and practise using an instruction sheet. In the intervention phase, 50% of the participants were assigned to the positive bedtime routines group and 50% to the bedtime fading group. Parents were implementing the prescribed activities and collecting data according to the sleep diary; each parent was collecting data individually. The study results suggest that parents implementing bedtime fading can yield successful outcomes in children with ASD; it increases the sleep duration and decreases the sleep onset latency for 100 % of participants.On the other hand, results obtained for the positive bedtime routines reported decreased sleep onset latency for all participants, but sleep duration increased only in two out of three participants. The parents positively rated both interventions. According to Delemere et al. (2017), when discussing stimulus control in the context of sleep, one should assume that for consistent sleep to take place, steps in the behavioural chain must come under stimulus control of appropriate discriminative stimuli. Considering those findings from a strengthening perspective would indicate that each discrete response emitted by a child and then reinforced by the parents facilitated the intervention's success. For example, in the bedtime fading condition, it would mean accomplishing sleep onset within the set target (below 15 min) or increasing total sleep duration by one hour and receiving positive social feedback immediately afterwards facilitated the results.

However, analysing the findings from the signalling perspective simplifies the

task, which is exceptionally well illustrated in the bedtime fading condition. The final aim of the intervention was an increase in total sleep duration, improvement of sleep onset latency and decrease in frequency and duration of night awakenings; hence the result of the intervention was based on the overall pattern of sleep behaviour and not on unitary responses. The overall length of positive bedtime routines is a continuous measure that does not translate well to discrete responses.

Assessing Stimulus Control and Promoting Generalisation via Video Modelling when Teaching Social Responses to Children with Autism

In their study, Jones et al. (2014) aimed to access stimulus control and promote the generalisation of social responses in children with ASD. The study consisted of baseline, training and generalisation probes. During the baseline condition, a therapist would provide a verbal prompt upon which a child had 10s to respond accordingly (by engaging in the social response); there were 10 trials in one session. If a child answered correctly, a reinforcer was delivered. The generalisation sessions were identical to the baseline ones, with the only exception being the interventionist (either another adult or a peer trained by the leading interventionist). The training phase consisted of a similar procedure as the baseline. However, in the training phase, the response time was shorter, a child had 5s to emit the response, and in case it did not respond, a verbal prompt was delivered. The generalisation of social responses across different adults and peers in Jones et al.'s (2014) illustrates the future-orientated nature of stimulus control. Children had previous experience with adult therapists before participating in the experiment; hence the presence of an adult versus peer in the trial signalled that reinforcers are possible to obtain. Participants' performance with different adults was identical during the initial generalisation probes and the training. The levels of responding with peers were substantially lower than those with adults. The presence of the peer per se or an absence of the adult in the trial controlled the participant's performance, hence served as a signpost of the possible future reinforcer as generalised from the past experience with the adults (children had previous experience rich in reinforcement with adult interventionists in the Center).

If learning (acquisition and generalisation of the social response) had occurred due to response strengthening, the change in behaviour (a successful generalisation of the acquired social skill) would have been caused by reinforcing the most recent response (the last produced social response), which could not explain why performance was different with peers than with adults. The procedure, materials, settings and reinforcers were identical in both conditions, with the only difference being the peer or adult. The presence of the adult signalled possible future events, and participants learned to behave accordingly. Jones' et al. (2014) participants had experience with adult interventionists, who had previously often delivered reinforcers in other contexts facility.

The Use of Stimulus Control Transfer Procedure to Teach Motivation-Controlled Mands to Children with Autism

The purpose of Ward et al.'s study (2019) was to explore if mand training utilising a stimulus control transfer procedure would help children to obtain and generalise mands for specific activities or objects induced by motivating operations Mands, especially motivating operations (MO) mands, are socially significant, similarly to the natural requesting behaviours observed in typically developed children (Ward et al., 2019). Mand is a verbal operant introduced by Skinner (1957) together with"tacts", "echoic" "intraverbals" etc. A mand is an utterance expressing a demand which a listener reinforces. MO manding is regarded as an advanced form of verbal behaviour. In MO manding, a motivation to gain access to a highly preferred item is present even when

the item is not visible or physically available to a child. When the child mands for this particular item, its behaviour is reinforced by a listener who grants access to the item. Ward's et al. procedure consisted of three phases: baseline, intervention, and generalisation. In the baseline, the participant's task was to mand for a visible item available at the table without a prompt; upon emitting the correct response, children were praised and received a reinforcer. During the intervention phase, highly preferred reinforcers were briefly shown to the participants and then hidden away. Upon responding correctly during the trial, the highly preferred item was made visible again without any prompt. If a child manded for it, a small amount of it (if it was an edible item) was immediately given to them. Afterwards, the highly preferred item was again removed from the participant's view, and the subsequent trial would begin. In the generalisation phase, participants' manding was accessed in the natural environment during classes or other naturally occurring school activities. Data were collected on whether they manded spontaneously for the trained or untrained targets. The results demonstrated that 90% of the participants used MO mands consistently after the skill acquisition. In the strengthening view, one member of a particular class of behaviour has to be followed by a member of another class, i.e., a member of the response class (producing a mand) is followed by a member of the reinforcer class (access to the requested item) and hence the response is strengthened and more likely to occur more often in the future (participant will mand more frequently in the future). However, the strengthening perspective does not serve the interpretation of the results well. The criterion to transition to the next phase of the study required a participant to demonstrate an increase in an overall acquisition of MO mands (50% higher than in the previous phase); hence the overall pattern of responding was the dependent measure. Furthermore, the overall results of the intervention were due to successfully established behaviour patterns (overall manding) extended in time instead of a discrete, momentary response (each mand). Ward and colleagues define the dependent variable as MO-controlled mands measured as time spent responding (manding), which had to occur within 15s upon presenting the highly preferable item. No discrete dependent variable enters the picture.

The successful skill acquisition and generalisation in three out of four participants were possible because of the use of multiple, repeated trials (in which a child would produce an unprompted request for a specific item). Through those repeated trials, participants built a learning history where a functional class of responses (correct manding) produced the reinforcers in the presence of MO (Ward et al., 2019). From the signalling perspective, participants' manding was controlled by their earlier pattern of responding (mands emitted in the previous trials) and the verbal cues/3s presentation of the possible reinforcer available in the current environment.

Discussion

Overall Comments

The current literature contains a variety of ABA-based interventions to teach skills or reduce problem behaviour and increase compliance in children with ASD. All aim at understanding how the past contributes to current behaviour. Here we presented two approaches to answer this question, the traditional strengthening view and the more recently introduced signalling perspective. We showed how the success of several interventions ranging from increasing communication repertoire to compliance and sleep behaviours could be straightforwardly interpreted from a signalling perspective, avoiding the pitfalls of the concept of behavioural strength as discussed at length by Simon et al. (2020). The overall conclusion of this review is that it was the successfully established stimulus control in various forms across the studies (a verbal cue in Ingvarsson,

2016; Ward, 2019, a novel therapist in Borgen, 2017, or a presence of an adult in Jones, 2014) that perpetuated the behaviour change based on the extended past experience (relation between reinforcers and overall pattern of responding) in those interventions. The results of the interventions mentioned above cannot be accounted for smoothly with a focus on strengthening of the most recent responses.

Limitations

Inclusion criteria present a possible limitation of the study. The current review only surveyed articles that were published in English language peer-reviewed journals. Our specific inclusion criteria may have excluded several studies such as 'grey' literature (thesis, dissertation monographs, etc.). Moreover, studies needed to include at least 4 participants diagnosed with ASD, aged 2–10 years old. In hindsight, this particular inclusion criterium may have been too stringent and may have contributed to the relatively low number of studies included in the review.

Future Research

In this review, several interventions utilising stimulus control ABA-based techniques were effective, such as those aiming to expand communication repertoire (Ingvarsson, 2016; Jones et al., 2014; Ward, 2007) or increase compliance (Borgen et al., 2017) in children with ASD. It would be advantageous for basic and applied behaviour analysis if more studies were conducted explicitly from the signalling and the strengthening perspective. The signalling perspective takes a molar view on behaviour, which is unknown to many applied researchers. Designing applied studies from a molar perspective would be a unique opportunity for collaboration between clinicians implementing ABA interventions for children with ASD and researchers from basic and applied research fields whose interests lie in molar behaviourism. Molar behaviourism is an alternative to radical behaviourism, focusing on how behaviour comes under the control of correlations of events in the environment.

Conclusion

In the current review, five studies were examined. All of the studies reported overall positive results. The interpretation of these studies from the two alternative perspectives sheds additional light and adds value to the obtained outcomes. However, in our opinion, the majority of these results are more straightforwardly understood from a signalling perspective than a strengthening perspective, especially when taking into account the pitfalls of the concept of response strength elaborated upon elsewhere (Cowie et al., 2019); Shahan, 2017); Simon et al., 2020).

Our analysis carries the potential to inform basic scientists about the practical relevance of their research and aims at inviting colleagues working on applied studies to broaden the conceptual basis of their work. They may significantly improve their interventions' effectiveness and theoretical consistency by designing them from the signalling perspective.

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Paper 2

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ORIGINAL ARTICLE

Control of Transition Time by the Likely Future as Signalled from the Past in Children with ASD

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Abstract
The signaling perspective offers an alternative to the Skinnerian view of understanding behavior. The signaling effects of reinforcers have predominantly been explored in the laboratory with nonhuman subjects. To test the implications of this view for applied behavior analysis, we contrasted the effect of discriminative stimulus versus reinforcer control in children with autism spectrum disorder (ASD). We aimed to determine whether the duration of their transitions from one reinforcer context to another is controlled by their most recent past or the likely future based on more extended past experience. Reinforcer context (rich, moderate, or lean) was signaled in the first condition. We observed that transition times to the leaner reinforcer were longer than those to the richer. The reinforcer context was unsignaled in the second condition. The differences between transition times disappeared in the second condition. The difference in durations of transitions to signaled and unsignaled reinforcer densities suggests that behavior is primarily controlled by signals of likely future reinforcers as extrapolated from *extended* past experience rather than strengthened by *the most recent* event.

Keywords Stimulus vs. reinforcer control · ASD · Transitions

The main concern of all behavior analysts is how the behavior and the environment of organisms interact. Both behavior analysts working in experimental laboratories and those working in the applied field try to partition the stream of environmental events and behavior into measurable units to understand their interaction. Those raised in Skinner's tradition (Skinner, 1938) usually partition the interactions into discriminative stimuli, responses, and reinforcers. Discriminative stimuli are understood to be the antecedents of responses, which signal when specific response types (members of response classes) will produce reinforcers, which in turn will strengthen the response class in the sense of making the future appearance of this kind of responses more likely (Skinner, 1938, 1953). For strengthening to occur, reinforcers need to be delivered contingent on responses. For Skinner (1948, 1953), a contingency was primarily defined by temporal contiguity between responses and reinforcers. In "'Superstition' in the pigeon," he explicates that "[t]o say that a reinforcement is contingent upon a response may mean nothing more than that it follows the response . . . conditioning takes place presumably because of the temporal relation only, expressed in terms of the order and proximity of response and reinforcement" (Skinner, 1948, p. 168).

However, during the past decades, evidence in favor of a more parsimonious partitioning of the behavior–environment interaction has been accumulating, questioning if contiguity is the primary defining characteristic of a contingency. Moreover, many experimental results suggest that the signaling properties of environmental events are sufficient to explain the effects of reinforcers. Accounts of behavior based on a contingency between environmental events with signaling properties and behavior render the concept of response strength superfluous, which is a good thing due to plenty of theoretical problems with the concept (see, e.g.. Baum, 2002, 2012; Cowie et al., 2011; Cowie & Davison, 2016; Simon et al., 2020, for elaboration). Several terms have been suggested for environmental events that guide behavior. Cowie et al. (2017) called them "signals," Shahan (2010) called them "signposts," Baum (2018) called them "inducers" and "phylogenetically important events" (Baum, 2012), and Borgstede and Eggert (2021) called them "statistical fitness predictors." We will continue to speak of the signaling effects of "reinforcers" to facilitate readability for

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a behavior-analytically trained audience. In this translational study, which aims to be informative for both an applied and a basic scientific audience, we prioritize comprehensibility. However, we wish to move beyond the "re-in-forcing" or "strengthening" connotation in the sense that the words are used in material sciences (see Shahan, 2017, for a more detailed discussion of this terminology[1]). Although we write of the signaling effects of "reinforcers," we reserve the term "reinforcement" for the process of strengthening by reinforcement in Skinner's (1938) sense.

Next to wishing to get a better understanding of the dynamics of transitions in children with ASD, our interest in the role of signaling effects has been catalyzed by the following findings, which do not fit smoothly in Skinner's (1938) contiguity-based paradigm of response strength modulation by reinforcement:

The signaling properties of reinforcers appear to account smoothly for response patterns on fixed-interval (FI) and fixed-ratio (FR) schedules. The absence of or decreased responding following food delivery on FI and FR schedules may occur because each obtained food pellet signals the beginning of a period when no food pellets will be delivered as long as the schedule alternates in such a way that the last food pellet predicts the next one (Cowie et al., 2011; Cowie & Davison, 2016). Ferster and Skinner (1957) first observed the postreinforcer pause. They concluded that the absence of a reinforcer after several responses have been made or after a fixed time elapsed serves as a discriminative stimulus.

The discriminative function of reinforcers also accounts for Davison and Baum's (2006) results on conditioned reinforcer effects. They used frequently changing concurrent schedules procedures in which the relative rates of primary reinforcers varied across unsignaled components with seven different food delivery ratios arranged during the session. In the first experiment, certain reinforcer deliveries (food) were replaced with the display of a food-magazine light alone. Because the magazine light was paired with food, they assumed it would constitute a conditioned reinforcer. Both food and magazine-light delivery produced preference pulses at the option that generated them, but the magazine-light pulses tended to be smaller. Thus, they concluded that stimulus presentation served as a signal for where food was likely to be obtained. In their second experiment, they investigated the role of pairing a stimulus with food delivery by arranging a similar procedure as in the first experiment, but using a brief color change of the key light that was never paired with food. They observed that if the stimulus predicted more food on the same option, the preference pulse occurred on that option. However, if the stimulus predicted food on the other option, the pulse would occur on the other option. A process of strengthening by reinforcement, however, would predict that the pulse occurs on the last reinforced option instead. This did not happen. In other words, because the correlation of the stimulus with the location was important and pairing the food with the stimulus did not matter, conditioned reinforcer effects seem to be best understood as signaling effects.

Krägeloh et al.'s (2005) data also suggest that environmental events' signaling rather than strengthening properties account for behavior. They presented two keys producing food pellets to pigeons. Food was available contingent on a pigeon's pecking the key not most recently pecked, i.e., it was contingent on switching pecking location. Pigeons readily learned to alternate between the keys. If the most recent behavior had been strengthened, the pigeons would have pecked in the same location again. However, the extended pattern of food availability (contingent on not having pecked in the same location for the last food delivery) signaled where food would be available next. Quickly learning this behavioral switching pattern makes sense from a phylogenetic perspective because organisms often consume resources that deplete in a specific location after consumption. Having consumed the resource will signal that a location switch will generate more of that resource.

In a similar setup with children as subjects, Cowie et al. (2021) let participants play a game in which some responses could produce a reinforcer. If the participant chose the same response for the second time in a row, they would experience the lowest likelihood of the same reinforcer being available again in the same spot. By and large, children switched from the just successful response to the alternative one, which is difficult to explain based on the concept of response strength which would predict repetition of the last response occurring before the reinforcer. Instead of reinforcing the last response, the reinforcers presumably signaled that switching is required to obtain the next reinforcer.

In *Science and Human Behavior* (1953), Skinner clarified once more that, in his view, contiguity between responses and reinforcers was *the* central characteristic of effective reinforcers: "So far as the organism is concerned, the only important property of the contingency is temporal. The reinforcer simply follows the response. . . . We must assume that the presentation of a reinforcer always reinforces something since it necessarily coincides with some behaviour" (p. 85). To contrast between strengthening and (mere) signaling effects, Simon and Baum (2017) tested how contiguous and noncontiguous reinforcers affected human speech. In their systematic replication of Conger and Killeen's (1974) experiment on matching in conversations, Simon and Baum

[1] For the readers entertained by a discussion of appropriate terminology beyond the scope of this article, we can note that the verbs "reinforcing" and "strengthening" cannot be distinguished in the Germanic as well as in some Slavic (Polish and Russian) languages because both English words correspond to the same Germanic and Slavic word.

investigated speech and gaze allocation in conversations with two different interlocutors. In one condition, confederates delivered approval (a putative reinforcer) contingent on the participant's gaze and speech, creating a contiguity between talking to a specific confederate and her approval. In the other condition, approval was delivered independently of whom the participant looked at when talking. If the participant's gaze directed at a specific confederate had been strengthened by approval, the contiguity condition would have produced different relative gaze rates from those in the noncontiguity condition. Results showed no such difference between conditions, suggesting that the confederates' speech induced participants' gaze and speech.

Motivated by these experimental findings, which suggest that the signaling effects are most central to explaining behavior, we designed a study contrasting strengthening effects with mere signaling effects in a setting close to home for applied behavior analysts. To build a bridge to applied behavior analysis, we extended a procedure first used by Jessel et al. (2016). Although Jessel et al. (2016) originally designed their study to evaluate transition characteristics of human and nonhuman subjects, we found their procedure suitable to test if the signaling properties of environmental events can fully account for transition times or if strengthening by reinforcement will explain additional variance in transition times.

We choose to apply our interest in signaling effects to an investigation of transitions in children with ASD because transitions between activities are an integral part of everyday life, taking up to 25% of time daily (Sterling-Turner & Jordan, 2007) and often cause challenges such as stereotypy, physical aggression, dawdling, noncompliance with instructions and tantrums (Brewer et al., 2014; Castillo et al., 2018). Those difficulties usually arise during the process of shifting from one situation to another. In this context, the term "transition" implies that the period between the conclusion of one situation and the beginning of the next presents challenges (Luczynski & Rodriguez, 2015). This transitional period can occur when there is a requirement to organize previously used materials and distribute new ones (i.e., in a classroom), or change physical locations (i.e., moving from the floor to the table; Luczynski & Rodriguez, 2015). In other words, the structural features of a transition include "(a) termination of the pre-change context, (b) initiation of the post-change context, and (c) the period between the two contexts" (Luczynski & Rodriguez, 2015, p. 153).

Transitions between activities have been studied both in basic and applied experiments. The focus is often placed on transitions to the less favorable context because that is when challenges occur. Advance notice is one of the procedures that can reduce the challenging behavior because it signals the end of the current activity and announces the upcoming transition to another one ahead of time (Brewer et al., 2014; Toegel & Perone, 2022). However, both basic and applied studies have also produced the opposite result, suggesting that also signaling the transition to a leaner context slows them down (Castillo et al., 2018; Jessel et al., 2016; Langford et al., 2019). In operant labs, transitions between activities are usually studied using multiple FR schedules as in Perone and Courtney (1992). In their study, multiple FR schedules consisted of different components that resulted in access to varying reinforcers magnitudes. For instance, access to grain for one second was considered a "lean" reinforcer, whereas 7-s access was considered a "rich" reinforcer. During the experimental session, the components were presented in a quasirandom order, ensuring an equal number of transitions between the different reinforcer magnitudes: lean-to-lean, lean-to-rich, rich-to-lean, and rich-to-rich. The different discriminative stimuli (key color) signaled the forthcoming reinforcer magnitude. Perone and Courtney (1992) discovered that pauses were up to nine times longer during the transition from a rich reinforcer to a lean reinforcer compared to all other types of transitions. When the same transitions were arranged in a mixed schedule (when two or more component schedules alternate, with all components accompanied by the same stimulus), longer pauses tended to occur after components with rich reinforcers, although these pauses were generally much shorter than the pauses observed during the rich-to-lean transitions in multiple schedules (when two or more component schedules alternate, each correlated with a distinctive stimulus).

Perone and Courtney (1992) concluded that one of the functions of pausing was to signal the upcoming context. Pausing was reduced when transitions to leaner contexts were unsignaled. Similar results were observed in applied studies such as run by Brewer et al. (2014) and Jessel et al. (2016) where dawdling was observed during signaled rich-lean transitions.

In the study whose procedure inspired our design, Jessel et al. (2016) examined transitions between different reinforcers in children with ASD. Children walked from rich to rich, lean to lean, rich to lean, and lean to rich reinforcers. The transition to a lean reinforcer (a less preferred toy) took the children significantly longer than the transition to a rich one (a more preferred toy). This phenomenon was observed in the first condition of the study, where the color of the playmat the children were transitioning to matched the reinforcer richness. Green and yellow mats signaled rich reinforcers, and blue and red signaled lean reinforcers. For example, when asked to transition to the green mat, they would always have access to their preferred toy. Only the less preferred toy was available when they were asked to transition to the blue mat. In the second condition, the upcoming reinforcer was unsignaled. This removed the differences in transition time. In that condition, the colors of the mats did not correspond to the availability of certain

toys as in the first condition. As a result, the likely future was no longer predictable from the extended past experience, with the color of the playing mats matching the availability of preferred or less preferred toys. These findings suggest that the availability of discriminative stimuli signaling the reinforcer richness waiting after the transition was responsible for the duration of the transition and problem behavior that accompanied it during shifts to the lean reinforcers. It was the likely future (toy they were going to, signaled by the mat color) and not the immediate past (toy they were coming from) that controlled their behavior (degree of dawdling) when signals (mat colors with 100% correspondence to reinforcer richness) were available.

In addition to using Jessel et al. (2016) design to illuminate a different question, we extended it by adding a moderate reinforcer richness because the spectrum of contexts that organisms are experiencing exceeds two-dimensional rich-lean contexts. We also used continuous instead of discrete reinforcers because most behavior analytic studies have been conducted with discrete reinforcers (foot pellets). In contrast, many real-life reinforcers are continuous as they consist of (access to) activities. Furthermore, we applied measures (described in detail in the methods section) to ensure procedural fidelity during data collection that we found was missing in Jessel et al.'s study.

Our experiment aims at contrasting the effects of stimulus versus reinforcer control in children with ASD during transitions among three different reinforcer contexts in two conditions. We assessed signal versus reinforcer control by comparing transition times between a condition where the upcoming reinforcer richness was signaled and a condition where the upcoming reinforcer richness was unsignaled.

Method

Participants

Four children diagnosed with ASD participated in the experiment. Their names were changed to protect confidentiality. All participants were 5-year-old males with at least some verbal repertoire, good listener and motor skills, and could follow the instructions that were required to participate in the study.

Video watching was a highly preferred activity for all participants. None of the participants engaged in problem behavior that could have interfered with performance during the experiments. We would have terminated the trial if problem behavior had occurred. All children received early intensive behavioral intervention services provided to them at their (typical) kindergartens.

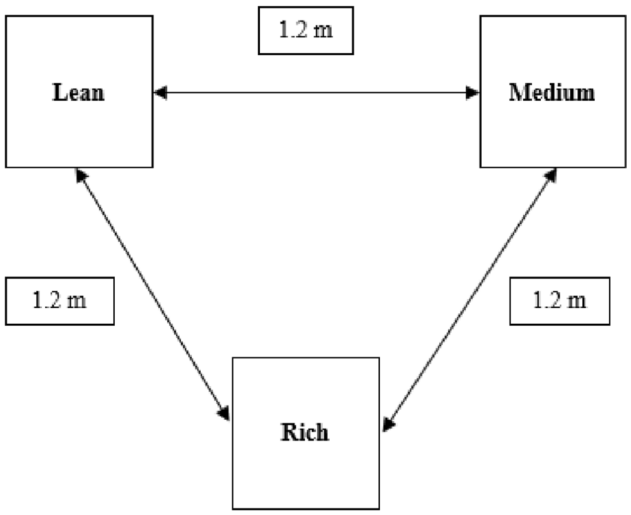

Fig. 1 A Diagram of the Setting Used in the Predictable and the Unpredictable Condition. *Note.* The arrows represent the distance between the mats; each mat represents a specific reinforcer context (rich, moderate, or lean). The mats were always placed in the shape of a triangle. The position of each mat varied between the trails

Settings and Materials

All sessions took place at the children's kindergartens in a small treatment room (5m x 4m) containing three playmats, a Samsung tablet, a timer, and a chair for the observer. Each trial lasted approximately 10–12 min and was scored by an independent observer to ensure interobserver agreement (IOA) and procedural integrity. We used three different color playmats (green, blue, and yellow, arranged in a triangular shape, see Fig. 1 for details) placed on the floor within a 1.2m distance from each other. To measure the time it took participants to transition among mats, play the videos, and provide visual prompts, we used the TapTimer app on the Samsung tablet. The TapTimer was explicitly developed for this research. It is an Android application that measures the transition time, displays the visual prompt with the color of the mat, and plays videos with a button press. Hence, the multifunctioning TapTimer application allowed the experimenter to control testing environment and reduce the number of devices needed to conduct the study such as additional timers, pen, and paper forms etc. The app also allowed the experimenter to transfer data on the duration of transitions to software for further analysis.

Procedure

All children participated in the experimental sessions three times a week. Each session consisted of three to four trials. Each trial compromised of a set 24 transitions between three playmats. A video preference assessment was conducted before the beginning of the experimental sessions. In the

Table 1 Transitions Time Mean (M) and Standard Deviation (SD) for All Participants in Both Conditions

	Lean-Rich		Moderate-Rich		Lean-Moderate		Moderate-Lean		Rich-Moderate		Rich-Lean	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Predictable Condition												
John	6.4	1.03	7.28	0.71	10.74	0.03	8.81	0.06	9.16	0.04	11.26	0.07
Joe	4.55	0.07	4.93	0.08	6.12	0.06	6.2	0.07	5.36	0.06	7.5	0.05
Tom	4.11	0.09	5.33	0.06	5.42	0.08	10.25	0.09	9.9	0.08	12.47	0.07
Ben	4.77	0.16	5.2	0.15	5.34	0.15	8.21	0.13	9.46	0.14	11.5	0.15
Unpredictable Condition												
John	7.34	0.04	7.64	0.05	7.4	0.04	7.74	0.07	7.3	0.03	7.4	0.05
Joe	8.96	0.04	8.83	0.05	8.88	0.05	8.74	0.04	8.74	0.05	8.49	0.05
Tom	8.91	0.04	8.53	0.05	8.46	0.04	8.19	0.04	8.77	0.05	8.65	0.04
Ben	8.97	0.04	8.82	0.05	8.78	0.07	8.66	0.05	8.46	0.03	9	0.06

Predictable Condition, the upcoming reinforcer context (rich, moderate, or lean) was signaled. On the green mat, a rich reinforcer was available (30-s video); on the yellow mat, a moderate reinforcer was available (10-s video). On a blue mat, a lean reinforcer was available (5-s video). In the Unpredictable Condition, the upcoming reinforcer context (rich, moderate, or lean) was unsignaled, meaning it could be rich, moderate, or lean, independent of a mat's color.

Preference Assessment

The type of video chosen for each participant was based on the results of multiple stimulus without replacement assessment (MSWO; DeLeon & Iwata, 1996). It consisted of different geometric illusion videos (see Table 1 for details) and was performed before each experimental session. (The results of the MSWO are available on request.) Watching geometric illusion videos was primarily found to function as a reinforcer for the behavior of children with ASD (Eldevik et al., 2019). For each participant, watching videos was ranked the highest on average and was included in the procedure (chosen from an array of other objects such as small toys and bricks). The video chosen by each participant was loaded into the TapTimer app before each experimental session. The videos were only shown to the children when on the playmats.

Experimental Sessions

Each trial within the experimental session lasted for 10–12 min. At the beginning of each trial, the experimenter opened the TapTimer app and said, "Go to green/ yellow/ blue mat," based on the color specified by the app following the experimental design. A transition duration was defined as time spent travelling between two mats starting after the delivery of the instruction and concluding when making physical contact with the destination mat. When the transition was successfully completed the experimenter stopped the timer and the video started playing automatically. The participant was given continuous access to watch the video while making physical contact with the mat up to the time limit set by the reinforcer context. The tablet, which was used to play a video, was held by the experimenter approximately 30 cm from the child. No child attempted to touch the tablet nor to interact with the experimenter. When the video stopped playing, the experimenter would prompt the child by saying: "Go to [color of the mat]" while presenting the tablet displaying the next mat's color. The color of the square presented on the tablet was the exact representation of the color of the mat the child was supposed to go to. When the child initiated the transition, the experimenter started the timer and returned to the middle of the triangle, where she remained until the child arrived on the prompted playmat. There were no instances of a child transitioning to the wrong area or refusing to transition. However, if that had occurred a verbal prompt would have been repeated once and if that had not resulted in the correct transition, the trial would have been terminated. Each trial consisted of a set of 24 transitions leading to an experience of eight rich, eight moderate, and eight lean contexts, with the initial context serving as the final context. (See Fig. 1 for an illustration.) Regardless of the context the child started from, it always experienced 24 transitions, four of each type (rich-moderate, rich-lean, moderate-rich, moderate-lean, lean-rich, lean-moderate). Reinforcer context was determined by the length of the geometric illusion video available on the tablet. The order of the transitions was randomized across the trials.

The Predictable Condition: Signaled Reinforcer Context

In this condition, the color presented by the tablet signaled the upcoming reinforcer context. Each time a green square was visible on a screen, it meant an upcoming experience of the rich context (30-s video), a yellow one meant moderate context (10-s video), and the blue square meant lean context (5-s video).

The Unpredictable Condition: Unsignaled Reinforcer Context

In this condition, the color presented by the tablet did not signal the upcoming reinforcer context. A participant could experience rich, moderate, or lean reinforcer context on each mat, with a 33.3% chance of it being one of the possibilities.

Interobserver Agreement and Procedural Integrity

The data were collected by the first author using the TapTimer app throughout the study in addition to trained observers who attended and scored 100% of the sessions for each participant. The trained observers used a timer application on their phones to measure transition duration and then transferred the scores onto the table. IOA scores of the transition duration were calculated by dividing the shorter duration by the longer duration, converting the quotient to percentage, and averaging across trials within the session. John's average IOA score was 97%, with the low score of 95% and high score of 100%. Joe's average IOA was 95%, with the low score of 91% and high score of 100%. Tom's average IOA score was 98%, with the low score of 94% and high score at 100%. Ben's average IOA was 97% with the low score of 89% and high score of 100%. We implemented a similar procedure to calculate procedural integrity as Shvarts et al. (2020). A checklist separated each session into the following four sections: (1) MSWO was conducted before the session; (2) playmats were in the correct locations; (3) instructions were delivered; and (4) the correct video was loaded into the TapTimer app. Any errors within those four sections of the checklist received zero points for those sections. The procedural integrity was calculated for each session by dividing the total number of sections executed correctly by the total number of all sections (errorless and delivered with errors) and multiplying that number by 100 to receive a percentage. Procedural integrity scored 92% on average across conditions and participants. The individual procedural integrity score measured 90% for John, 92.5% for Joe, 95% for Tom, and 92.5% for Ben. (Detailed data is available on request.)

Results

The transition times between different reinforcer contexts in the Predictable Condition varied according to the upcoming context, but not in the Unpredictable Condition. Figure 2 shows transition time across sessions during the Predictable Condition and the Unpredictable Condition. All children's transition times were longer when walking towards the leaner context in the Predictable Condition. Those results are in line with the existing research (Jessel et al., 2016; Langford et al., 2019; Perone & Courtney, 1992). However, differences occurred between John and the other three boys. John's transition times were longer than other participants (see Fig. 3); for example, in Lean-Rich transitions, his mean time transitioning was considerably longer with $M = 6.4$s, $SD = 1.03$, and $M = 4.55$s, $SD = 0.07$, $M = 4.11$s, $SD = 0.09$. $M = 4.77$s, and $SD = 0.16$ for Joe, Tom, and Ben, respectively. We observed only a slight difference between Rich-Moderate with $M = 9.16$s, $SD = 0.04$, $M = 5.36$s, $SD = 0.06$, $M = 9.9$s, $SD = 0.08$, $M = 9.46$s, $SD = 0.14$ for John, Joe, Tom, and Ben respectively, and Moderate-Lean transitions with $M = 8.81$s, $SD = 0.06$, $M = 6.2$s, $SD = 0.07$, $M = 10.25$s, $SD = 0.9$, $M = 8.21$s, $SD = 0.13$ for John, Joe, Tom, and Ben, respectively, in the Predictable Condition. Nevertheless, our procedure successfully showed that introducing moderate context can reduce the transition time when the upcoming context is signaled, as shown in Table 1 and Fig. 2. However, the most considerable difference was observed for all participants transitioning from Rich to Lean context (see Fig. 2) with $M = 11.26$s, $SD = 0.07$, $M = 7.5$s $SD = 0.05$, $M = 12.47$s, $SD = 0.07$, $M = 11.5$s, $SD = 0.15$ for John, Joe, Tom, and Ben, respectively.

In the Predictable Condition, the transition times from leaner to richer contexts were shorter across all participants, with the fastest transitions being Lean-Rich (values above), Moderate-Rich ($M = 7.28$s, $SD = 0.71$, $M = 4.93$s, $SD = 0.08$, $M = 5.33$s, $SD = 0.06$, $M = 5.2$s, $SD = 0.15$ for John, Joe, Tom, and Ben, respectively) and Lean-Moderate ($M = 10.74$s, $SD = 0.03$, $M = 6.12$s, $SD = 0.06$, $M = 5.42$s, $SD = 0.08$, $M = 5.34$s, $SD = 0.15$ for John, Joe, Tom, and Ben, respectively; see Fig. 2). Those results suggest that signaled upcoming reinforcers served as "signals," informing where and how more could be obtained.

However, we did not observe those differences in the Unpredictable Condition; all children's average response times were similar regardless of the upcoming reinforcer context. In this condition, we observed longer transition times from historically leaner to richer context compared with the Predictable Condition; for example, Lean-Rich transitions times were as follows: $M = 7.34$s, $SD = 0.04$, $M = 8.96$s, $SD = 0.04$, $M = 8.91$s, $SD = 0.04$, $M = 8.97$s, $SD = 0.04$, for John, Joe, Tom, and Ben, respectively. Similar transition times were observed in historically Rich-Lean transitions with $M = 7.4$s, $SD = 0.05$, $M = 8.49$s, $SD = 0.05$, $M = 8.65$s, $SD = 0.04$, $M = 9$s, $SD = 0.06$ for John, Joe, Tom, and Ben, respectively.

However, the transition times from the richer to the leaner context in the Unpredictable Condition did not exceed the transition times between those contexts in the Predictable Condition. Moreover, despite the longer transition times from leaner to richer context, the overall transition times were shorter compared to the Predictable Condition.

To examine the overall effects across sessions for each participant, Fig. 3 shows that average response times among

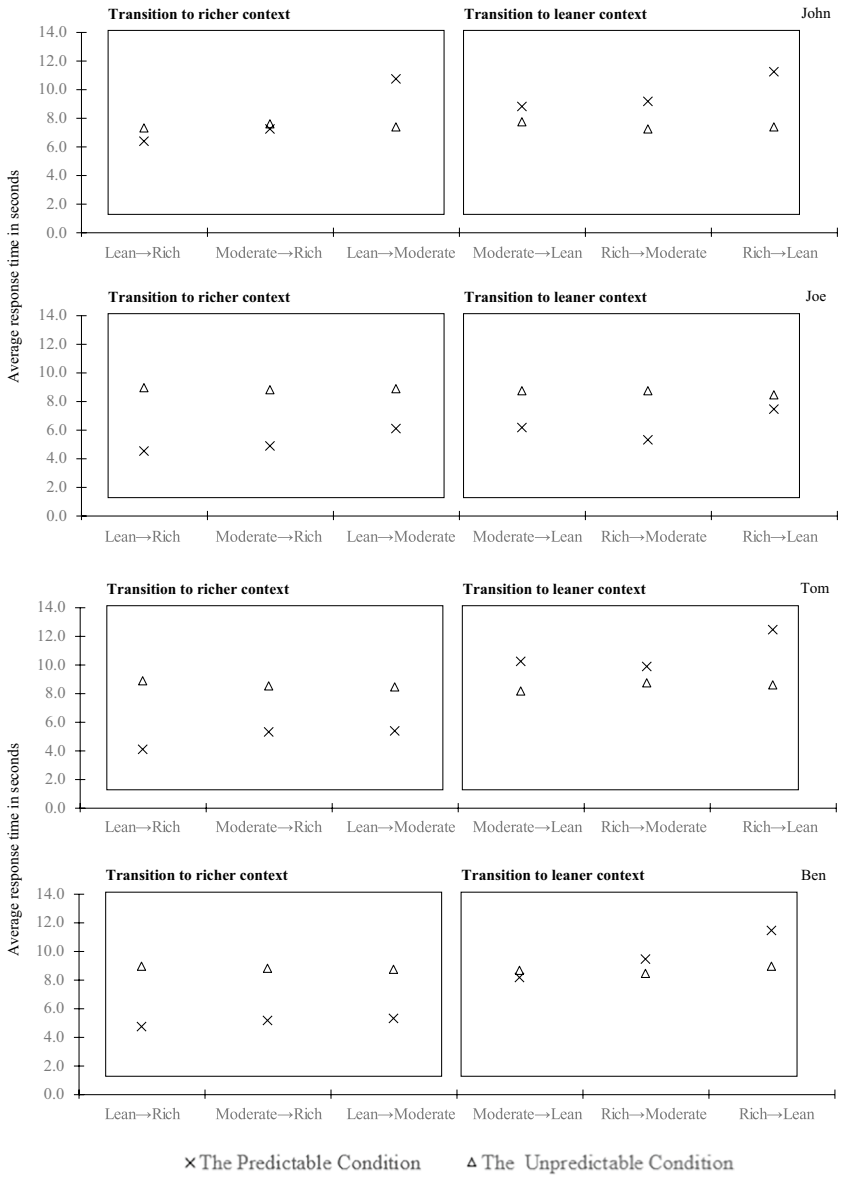

Fig. 2 Average Responses for Each Participant across the Predictable and the Unpredictable Condition

different reinforcer contexts were more similar across all participants during the Unpredictable Condition than the Predictable Condition. The difference in durations of transitions to signaled and unsignaled reinforcer contexts suggests that behavior is primarily controlled by signals of likely future reinforcers as extrapolated from extended past experience rather than strengthened by the most recent event (the most recently experienced reinforcer context).

Discussion

Our discipline's primary concern is understanding how behavior and the environment interact. Our findings add to the existing and growing body of research (Baum, 2018; Baum & Rachlin, 1969; Cowie et al., 2021; Cowie & Davison, 2016; Davison & Baum, 2006; Simon & Baum, 2017), suggesting that we do not need to rely on the hypothetical construct of response strength (Skinner, 1938) to explain this interaction. Reinforcers might not strengthen the response which they follow, but rather guide behavior to where and how more of them can be obtained. By replicating and extending Jessel et al.'s (2016) finding that transition times between different reinforcer contexts are controlled by the upcoming context and not by the previous one, our results provide further evidence for the importance of signaling properties of reinforcers.

Of interest to applied behavior analysts, we also replicated the finding that transition time to a leaner reinforcer context can be shortened by including an unsignaled reinforcer context (Jessel et al., 2016; Toegel & Perone, 2022).

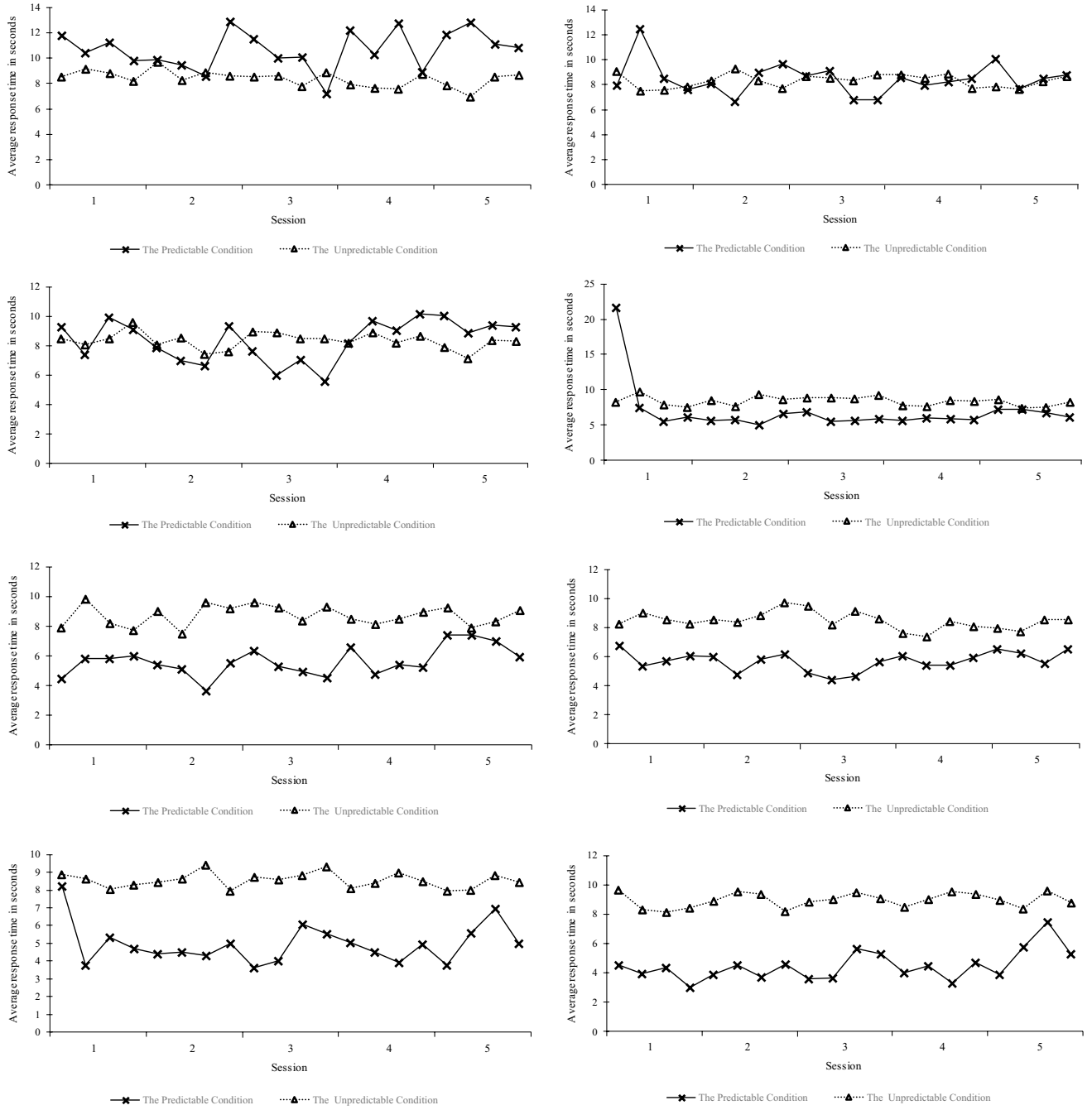

Fig. 3 Average Response Times for All Participants in both Conditions when Transitioning from One Context to the Other. Rich-Lean transitions, Rich-Moderate transitions, Moderate-Lean transitions, Lean-Moderate transitions, Lean-Moderate transitions excluding John, Moderate-Rich transitions, Lean-Rich transitions, Lean-Rich transitions, excluding John)

Differences in transition times among participants in unpredictable conditions were smaller than in predictable conditions. This finding has important implications and can be used as a part of an intervention plan to reduce problem behavior associated with transitions. For example, introducing an unsignaled reinforcer context can help shorten the transitions time when problem behavior during transitions is not maintained by the unpredictability of the upcoming activity, but rather by worsening in conditions (Matson, 2023). Also, in situations when termination of the preferred activity and initiation of a signaled aversive activity are accompanied by problem removing the signal can be useful however, completely removing all stimuli that signal the upcoming activity may be challenging (e.g., walking towards a table where typically nonpreferred activities take place; Brewer et al., 2014; Matson, 2023).

In instances when a functional analysis reveals that unpredictability, rather than the pleasant or unpleasant aspects of the situations, influences the problem behavior providing signals can help. Flannery and Horner (1994) observed that problem behavior occurred less frequently when the order and duration of activities were random but signaled, compared to when activities were random and not signaled. This suggested that predictability was functionally related to problem behavior. The assessment included a treatment condition where signals, functioning as discriminative stimuli, provided information about upcoming events, thus preventing problem behavior by avoiding the triggering of the establishing operation (Matson, 2023).

Thus, the decision whether signal the upcoming events should be based on the functional analysis, but also practical considerations. In emergency situations, the signals cannot be provided ahead of time and unpredictability cannot be avoided. Hence, a reasonable goal would be to gradually and systematically increase the percentage of transitions that are unsignaled while maintaining low levels of problem behavior (Luczynski & Rodriguez, 2015; Matson, 2023).

One potential limitation of the present study is that we only ran the signaled condition before the unsignaled one. By using a reversal design and repeating the signaled condition the signaling effects of the upcoming context could also have been validated. Another potential limitation is the homogeneity of the participants included in the study, due to several challenges with recruitment we were not able to include children with additional diagnosis or from different age groups. By diversifying participants, we would have been able to generalize the results further.

Our experiment shows that time spent transitioning changes according to the upcoming reinforcer context. Our results are in line with previous work on the signaling properties of reinforcers in humans and nonhumans (Baum, 1974; Cowie, 2018; Cowie et al., 2021; Cowie & Davison, 2020; Simon & Baum, 2017).

A three-term contingency could not explain our results because there is no evidence that the videos strengthened traveling (duration) because, for example, shorter traveling times following longer videos would have implied. If "what had happened most recently," that is, which reinforcer richness participants had just experienced had explained any variance in travel times, strengthening by reinforcement would have provided a reasonable explanation. However, the most recent video length did not account for any variance, only the signaled upcoming video length did, which aligns with the literature emphasizing signaling effects (Cowie et al., 2011; Cowie & Davison, 2016; Davison & Baum, 2006; Shahan, 2010; Simon & Baum, 2017).

In addition, our study extends previous investigations on transitions between different reinforcer contexts by adding a moderate context. Transition to or from moderate reinforcer contexts had not been investigated before, neither in basic nor in the applied experiments. Our results show that a moderate context can substantially reduce the transition time. A moderate context can be useful when teachers or caregivers want to avoid problem behavior associated with the lean context, but still maintain a demand to transition from a rich one. For example, instead of transitioning from playing outside (rich context) straight to completing math worksheets (lean context), a child may be asked to practice their reading (moderate context). Such modification can help reduce occurrence of schedule-induced problem behavior.

The increasing number of studies reporting that an advance notice procedure (Brewer et al., 2014; Toegel & Perone, 2022) is ineffective in reducing rich-lean transition times motivates further investigations including unsignaled moderate reinforcer contexts. This should include studies testing if our results can be replicated with adults, neurotypical children, as well as with nonhuman subjects.

In conclusion, our finding that transitions to leaner reinforcer contexts take longer in predictable conditions, shows the power of discriminative properties of reinforcers. This finding carries the potential to contribute to making these properties more known to applied behavior analysts, who are frequently unaware of the "signalling versus strengthening debate" (Wood & Simon, 2021). Translation of this debate among basic researchers to the applied field carries the potential to improve interventions aiming at improving socially significant behavior.

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Data Availability Data can be made available upon request from the corresponding author.

Declarations

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. The study was conducted under Approval 282790 granted by the Regional Committee for Medical and Health Research Ethics, Approval 931299 granted by the National Center for Research Data and Approval RITM0140084 granted by the University Faculty Ethics Committee. The study was conducted in partial fulfilment of the first author's PhD degree. Writ-

ten informed consent was obtained from the parents. Parents signed informed consent regarding publishing their children's data.

Conflict of Interest We have no known conflicts of interest to disclose.

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Paper 3

Signalling Effects during Transitions in Children

Author Note

We have no conflicts of interest.

Abstract

Results from basic experiments with non-human subjects and applied studies with children diagnosed with Autism show that transitions to a signalled leaner reinforcer context take longer than those to a richer one. When the upcoming context is unsignalled, the differences between transition times disappear. One possible explanation for this effect is the signalling properties of reinforcers. The signalling perspective suggests that behaviour is primarily controlled by signals of likely future reinforcers extrapolated from extended past experience rather than being strengthened by the most recent event. This study aimed to extend those findings to neurotypical children. Findings from this translational study support existing evidence that not signalling the upcoming context can reduce the transition time to leaner reinforcer contexts. Furthermore, adding a moderate reinforcer context can reduce the transition time from a richer to a leaner context by half, even when signalled. A moderate context can be useful for basic and applied researchers when designing procedures where transitions to a leaner context are signalled and unavoidable.

Keywords: stimulus vs. reinforcer control, transitions, children, translational research

Transitions between activities are an integral part of everyday life; hence, the ability to transition successfully is a developmental goal for pre-schoolers (Schmit et al., 2000; Sterling-Turner & Jordan, 2007). Findings from basic, applied, and translational studies (Jessel et al., 2016; Perone & Courtney, 1992; Toegel & Perone, 2022; Wood & Simon, 2023) show that most challenges accompany transitions to a less favourable context. A process of strengthening by reinforcement seems inapplicable to explain this phenomenon, since as reported by Wood & Simon, (2023), the length of the transition between different reinforcer contexts is not controlled by the previous reinforcer context, but by the signal of the upcoming one.

Strengthening versus Signalling

The primary subject matter of behaviour analysis is the behaviour-environment interaction. In the classic approach (Cooper et al., 2019), one assumes a three-term contingency consisting of antecedent (A), behaviour (B), and consequences (C). If a contiguous reinforcer follows behaviour, the behaviour will be strengthened, and we will observe more of it in similar circumstances (Skinner, 1938). This approach attributes great importance to the process of strengthening by reinforcers (Palmer, 2009). This approach served us well; however, accumulating evidence suggests that the signalling value of reinforcers can explain the environment-behaviour interactions more straightforwardly (Davison & Baum, 2006, 2010). Baum (2018b) proposed an example where stimulus and reinforcing properties can be attributed to the same environmental event, using the feedback function graph. In this graph, an environmental event serves a double function, and each is considered equally important. In Baum's nomenclature, an environmental event called a "conditional inducer" induces the behaviour (stimulus/ signalling function), and because the induced behaviour is in covariance with what he named a Phylogenetically Important Event (PIE) (Baum, 2012), such as food

(reinforcing function), we observe more of it as long as it satisfies the organism current needs (Baum, 2024, 2018a, 2018b). For example, food is a conditional inducer for a hungry organism; the covariance is positive when the hunger is satisfied by obtaining food (a PIE).

This approach offers an alternative worthy of consideration, especially in the context of transitions. For example, signalling control of the reinforcer context during transitions was observed in Perone and Courtney (1992) and other applied studies (Jessel et al., 2016), explained in detail below. During the last decades, many theoretical arguments (Baum, 2012, 2018; Cowie, 2020; Cowie & Davison, 2020; Shahan, 2010, 2017; Simon et al., 2020) and empirical results (Cowie et al., 2017, 2021; Simon & Baum, 2017) have questioned Skinner's (1948, 1953) interpretation of contingencies, which he defined as order and proximity between responses and reinforcers. Baum (2002, 2012, 2018, 2020), Cowie (2020), De Haan & Simon (under review), Shahan (2010, 2017), and Simon et al. (2020) argue that the concept of response strength is superfluous. Baum (2002, 2012) Simon & Baum (2017), and Cowie (2020), found no evidence for reinforcers strengthening the most recent response they follow. Instead, the stimulus function of "reinforcers" explains all there is to explain about behaviour change in ontogeny. In addition to "inducers" and "Phylogenetically Important Events" (Baum, 2012), various labels have been suggested for these environmental events which guide behaviour. Shahan (2010) called them "signposts", and Borgstede and Eggert (2021) called them "statistical fitness predictors". In this view, behaviour is explained by the signalling properties of reinforcers that guide an organism to where and how more of them can be obtained (Cowie et al., 2011; Cowie & Davison, 2020).

The discriminative function of reinforcers accounts for phenomena such as responding patterns on fixed-interval (FI) and fixed-ratio (FR) schedules. The absence of, or decreased responding following food delivery on FI and FR schedules may result from each obtained food

pellet signalling the beginning of a period when no food pellets will be delivered as long as the schedule alternates in such a way that the last food pellet predicts the next one (Cowie et al., 2011; Cowie & Davison, 2016).

The effect of so-called conditioned reinforcers is also plausibly explained by the discriminative function of reinforcers (Shahan, 2010). Davison and Baum (2006), investigated these using frequently changing concurrent schedules procedures in which the relative rates of primary reinforcers varied across unsignalled components with seven different food delivery ratios arranged during the session. In the first experiment, certain reinforcer deliveries (food) were replaced with the display of a food magazine light alone. Since magazine light was paired with food, it functioned as a conditioned reinforcer. Both food and magazine-light delivery produced preference pulses at the option that generated them, that is, strong, short-term responding on the most recently reinforced option in concurrent schedules. However, magazine-light pulses tended to be smaller. Hence, they concluded that stimulus presentation was a signal for where food would likely be obtained. In their second experiment, they studied the role of pairing a stimulus with food delivery by arranging a procedure similar to the first experiment but using a key light that briefly changed the colour that was never paired with food. They observed that if the stimulus predicted more food on the same option, the preference pulse occurred on that option. However, if the stimulus predicted food on the other option, the pulse would occur on the other option. As a consequence of a process of strengthening by reinforcement, one would expect that the pulse occurred on the last reinforced option instead. This did not happen. In other words, since the correlation of the stimulus with the location was important and pairing the food with the stimulus did not matter, conditioned reinforcer effects seem to be best understood as signalling effects.

The discriminative properties of reinforcers also account for the results obtained in Wood & Simon (2023), which suggested that behaviour during transitions between different reinforcer contexts is controlled by the upcoming reinforcer context rather than the most recent one. In this study, children transitioned between three different coloured mats. In one condition, the upcoming reinforcer context was signalled by the mat's colour; in the other condition, it was not signalled. The signalling properties of the upcoming reinforcer context were noticeable because the transitions in Wood & Simon (2023), were always arranged between different contexts (rich-moderate, rich-lean, moderate-rich, moderate-lean, lean-moderate, and lean-rich) and not the same contexts (i.e. rich-rich, moderate-moderate, lean-lean). In such a preparation, the upcoming context (the colour of the mat) signals either betterment or worsening of the upcoming condition. Such procedural differences between this study and the usual preparations in transition experiments (Perone & Courtney, 1992; Toegel & Perone, 2022) where the transitions are also arranged between the same contexts (i.e. rich-rich, lean-lean) highlighted the signalling properties of reinforcers. In Baum's terminology, the upcoming rich reinforcer context-induced rapid switching to it. In contrast, the upcoming lean reinforcer context-induced other activities that interfere with switching (such as dawdling observed in Jessel et al., 2016). Therefore, the transitions to the leaner context were slower.

Other observations most straightforwardly explained by reinforcers' signalling properties are negative reinforcement, especially avoidance (Baum, 2020), and responding on interval and ratio schedules (Baum, 2018b). The signalling perspective is explained in more detail by Cowie (2020), Shahan (2010, 2017), and Simon et al. (2020).

Basic Studies on Transitions

In the operant lab, transitions are typically studied using fixed-ratio (FR) schedules. Pausing is usually observed during rich-lean transitions before initiating the transition (Perone & Courtney, 1992; Toegel & Perone, 2022). In Perone and Courtney (1992), pigeons were studied under multiple FR schedules that resulted in either long (e.g. 7s: rich reinforcer context) or short (e.g. 0.5s: lean reinforcer context) food presentations in a randomised order in each session. The four different transitions (rich-rich, rich-lean, lean-rich, and lean-lean) occurred equally often in each session. They observed that both the upcoming and past reinforcers influenced pausing. However, significantly longer pausing (nine times longer than in other transitions) was observed after rich-lean transitions in the multiple schedule condition with the different discriminative stimuli (SD) signalling the upcoming reinforcer magnitude. Moreover, pauses were shorter before large reinforcers than before small ones. The response key (illuminated with different colours the entire session) which served as SD in the multiple condition remained unchanged in the mixed schedule component. It was illuminated with the same colour the entire session. Thus, subjects could not discriminate the upcoming reinforcer magnitude like in the multiple schedule condition. Due to that change, pausing was significantly shorter, even in rich-lean transitions. Perone and Courtney (1992), concluded that the previous and the upcoming reinforcer context determined the length of pausing.

Similar results were obtained by Toegel and Perone (2022), who studied the “advance notice” procedure in pigeons using a multiple schedule procedure with two FR components. Similarly to Perone and Courtney (1992), the lean component produced brief access to food, whereas the rich component produced longer access to food. Flashing of the house light served as advance notice during rich-lean transitions. Instead of reducing the transition time, it caused

extended pausing when it reliably signalled transitions to the leaner context. In conditions where advance notice (flashing of the house light) could produce access to either rich or lean reinforcer context, it did not affect the transition time. Similar findings were obtained in applied procedures (Brewer et al., 2014), especially when the transitions to the leaner reinforcer context were entirely predictable and when the transition-related problem behaviour was escape maintained. The authors concluded that the advance notice procedure has limited advantages and is recommended mainly when transition-related problem behaviour is due to uncertainty of the upcoming activity.

Langford et al. (2019), studied aversive stimuli causing extended pausing associated with rich-lean transitions in pigeons. The response key light signalling the transition type served as aversive stimuli. Their procedure allowed pigeons to either complete the FR schedule in the presence of a mixed-schedule stimulus or to choose a transition-specific multiple-schedule stimulus. In a mixed schedule, two or more component schedules alternate, with all components accompanied by the same stimulus. This means that the response key was illuminated with the same colour throughout the session and was not signalling the upcoming schedule. On the other hand, in a multiple schedule, two or more component schedules alternate, and each component is correlated with a distinctive stimulus. This means the response key was illuminated with different colours for each transition, signalling the upcoming schedule. The mixed schedule was preferred when the multiple schedule signalled a transition to a lean reinforcer context. However, the multiple schedule was preferred during signalled transitions to a rich reinforcer. Their findings again confirmed that stimuli associated with rich-lean and lean-lean transition have an aversive function.

The results from Langford et al. (2019), Perone and Courtney (1992), Toegel and Perone (2022) suggest that discriminative stimuli paired with the upcoming reinforcer context partially determine the transition time. Hence, the advance notice procedure can be recommended in an applied context to mitigate pausing during transitions (Castillo et al., 2018; Sterling-Turner & Jordan, 2007). However, its usefulness is limited to transition-related problem behaviour due to the unpredictability of the upcoming activity (Brewer et al., 2014). The advance notice procedure is not recommended when problem behaviour is associated with terminating a preferred activity and transitioning to a less preferred one (Brewer et al., 2014). In other words, signalling the upcoming activity can be useful when not signalling is associated with problem behaviour during transitions between different reinforcer contexts.

Applied Studies on Transitions

In applied studies, transitions were studied mainly in children with Autism Spectrum Disorder (ASD) because this population finds changes in the environment especially challenging (Moir & Johnson, 2021; Rosenkoetter & Fowler, 1986; Tullis et al., 2015). Studies found that the most common challenges associated with transitions are loss of instructional time (Ryan et al., 2021), especially for younger children (Vitiello et al., 2012), but also in classrooms with older children (Banerjee & Horn, 2013). Several procedures aim to mitigate those challenges, such as the advance notice procedure (Brewer et al., 2014), signalling transitions with visual and vocal prompts (Klintwall & Eikeseth, 2012), or not signalling the upcoming reinforcer context (Jessel et al., 2016; Wood & Simon, 2023).

For example, the findings from Jessel et al. (2016) are similar to those obtained in basic studies and indicate that transitions to a signalled leaner reinforcer context can be associated with

extended pausing and dawdling. In their study, children moved from preferred to less preferred toys and from less to more preferred ones. Similarly to pigeons in basic studies (Perone & Courtney, 1992; Toegel & Perone, 2022), children took longer to transition to less preferred toys and engaged in problem behaviour when the stimuli (colour of the play mat) associated with the upcoming reinforcer context (less preferred toy) was reliably signalled. However, when the upcoming toy was not reliably signalled in the second part of the study, the transition times were similar for both types of toys. These findings suggest that the availability of clear signals indicating the type of toy waiting after the transition influenced the duration of the transition and the accompanying problem behaviour. The likely future controlled children's behaviour, i.e. the toy they were going to, signalled by the mat colour, rather than the immediate past, i.e. the toy they were coming from. This was true when clear signals, i.e. mat colours with 100% correspondence to toy type, were present. Those results were replicated and extended in Wood &Simon (2023), where children also experienced transitions between different reinforcer contexts with the addition of a moderate context. Signalled transitions to a leaner reinforcer context were longer than those to a richer one; however, adding a moderate reinforcer context substantially reduced the length of the transitions. This finding suggests that the length of unavoidable signalled transitions to a leaner reinforcer context can be reduced.

Despite a plethora of basic and applied research on transitions between different reinforcer contexts, drawing unambiguous conclusions about what procedure should be considered the ‘gold standard’ is challenging because the methods, participants and other aspects of the studies differ substantially. Many applied studies were designed to address a specific clinical need; hence, the generality of their findings is limited. For example, as mentioned by Toegel and Perone (2022), across applied studies that investigated the advance notice procedure

variables such as the method of measuring disruptions during transitions, the types of transitions between activities, the timing when the notice was delivered, and the delivery of consequences for disruptive behaviour were defined and measured differently. Such methodological discrepancies among the studies prevent meaningful post hoc comparisons.

Translational Endeavours on Transitions

The importance of translational studies in behaviour analysis was explicated by Mace and Critchfield (2010), who highlighted how traditional behaviour analysis research focused mainly on basic science and pointed out the need for translational research to bridge the gap between basic science and real-world application. Translational research aims to improve the effectiveness and efficiency of behaviour analytic interventions; hence, it heavily relies on successful communication and cooperation between basic and applied behaviour analysts (Perone, 1985).

For example, Williams et al. (2011) conducted three experiments to replicate and expand Perone and Courtney's (1992) study on transitions between different reinforcer contexts described above. In their first study, adults with mild intellectual disabilities interacted with a touch-sensitive computer monitor to earn money. In Experiment 1, they manipulated both response requirements and reinforcer magnitude across the multiple-schedule components and successfully replicated the effects observed in pigeons across human participants. Analogously to the pigeons, all human participants demonstrated differentially longer pausing before the lean component of a two-component multiple schedule only when the lean component followed the rich component.

In Experiment 2, the stimuli that signalled the two schedule components were eliminated, leading to the elimination of extended pausing in the participants, similar to what had been observed in Perone and Courtney (1992). Overall, their findings generalized results from non-humans to humans.

Similarly Williams et al. (2011), the purpose of the present study was to bridge the gap between basic and applied research studying transitions between activities. Our study aims to contrast the effects of stimulus versus reinforcer control in neurotypical children and to extend previously obtained results from children with ASD during transitions between three different reinforcer contexts in two conditions. We assessed signal versus reinforcer control by comparing transition times between the condition where the upcoming reinforcer richness was signalled (multiple schedule) and the condition where the upcoming reinforcer richness was unsignalled (mixed schedule).

Method

Participants

Six neurotypically developed children participated in the experiment. Their names were changed to protect confidentiality. Two participants were five-year-old males, and four participants were five-year-old females. All children had good verbal repertoire, listening and motor skills and could follow the instructions required to participate in the study. The level of the skills was assessed as typical for their age by their parents and kindergarten teachers.

Video watching was a highly preferred activity for all participants. None of the participants engaged in problem behaviour that could have interfered with performance during the study. We would have terminated the trial if problem behaviour had occurred.

Settings and Materials

All sessions took place at the children's kindergartens in a small treatment room (6m x 5m) containing three playmats, a Samsung tablet, a timer, and a chair for the observer. Each trial lasted approximately 10-12 minutes and was scored by an independent observer to ensure interobserver agreement and procedural integrity. Throughout the entire study (both conditions), we used three different colour playmats (green, blue, and yellow, arranged in a triangular shape; see Figure 1 for details) placed on the floor within a 1.2m distance from each other. To measure participants' transition times between playmats, play the videos, and provide visual prompts, we used the TapTimer app on the Samsung tablet. The TapTimer was explicitly developed for this study. It is an Android application that measures the transition time, displays the visual prompt with the colour of the playmat, and plays videos with a button press. The app randomised the order of transitions before each trial. Hence, the multifunctioning TapTimer application allowed the experimenter to control the testing environment and reduce the number of devices needed to conduct the study, such as other timers, pens or paper forms. The app also allowed the experimenter to transfer data on the duration of transitions to Microsoft Excel for further analysis.

Procedure

All children participated in the experimental sessions two to four times a week. Each session consisted of two trials. Each trial consisted of a set of 24 transitions between 3 playmats. A video preference assessment was conducted before the beginning of the experimental sessions. A reversal A-B-A design was used with phases 1 and 2 of the Predictable Condition (Condition A). Phase 1 of the Predictable Condition consisted of five trials, whereas phase 2 of the

Predictable Condition consisted of four trials. The Unpredictable Condition (Condition B) consisted of five trials and was not repeated. The upcoming reinforcer context (rich, moderate, or lean) was signalled by the colour of the playmat in the Predictable Condition (multiple schedule). On the green playmat, a rich reinforcer was available (30s video). On the yellow playmat, a moderate reinforcer was available (10s video). On the blue playmat, a lean reinforcer was available (5s video). In the Unpredictable Condition (mixed schedule), the upcoming reinforcer context was unsignalled, meaning it could be rich, moderate, or lean, independent of a playmat's colour. In practice, it meant that despite the identical set-up as in the Predictable Condition, the colour of the playmat did not indicate the reinforcer context richness; for example, the green playmat could represent each of the reinforcer contexts with a 33.33% chance of it being rich, moderate, or lean. The same was valid for the yellow and the blue playmats, which meant that a child's behaviour could not reliably discriminate the upcoming reinforcer context richness by the colour of the playmat they were transitioning to. However, all other procedural details, such as design, length of the trail, and instructions provided by the experimenter, remained the same in the Unpredictable Condition.

Preference Assessment

The type of video chosen for each participant was based on the results of a multiple stimulus without replacement assessment (MSWO) (DeLeon & Iwata, 1996). It consisted of different cartoon-type videos and an array of other small objects and was performed before each experimental session. The results of the MSWO are available on request. For each participant, watching videos was ranked the highest on average and was included in the procedure (chosen from an array of other objects such as small toys). The video chosen by each participant was loaded into the TapTimer app before each experimental session. The videos were only shown to

the children when on the playmats and were not available for watching outside the experimental sessions.

Experimental Sessions

Each trial within the experimental session lasted for 10-12 minutes. At the beginning of each trial, the experimenter opened the TapTimer app and said, "Go to *the green/ yellow/ blue* playmat", based on the colour specified by the app following the experimental design. A transition duration was defined as time spent travelling between two playmats starting after the delivery of the instruction and concluding when making physical contact with the destination playmat. When the transition was completed, the experimenter stopped the timer, and the video started playing automatically. The participant was given continuous access to watch the video while making physical contact with the playmat up to the time limit set by the reinforcer context. The tablet, which was used to play the video, was held by the experimenter approximately 30cm from the child. No child attempted to touch the tablet nor to interact with the experimenter. When the video stopped playing, the experimenter would prompt the child by saying: "Go to the (colour of the playmat) playmat" while presenting the tablet displaying the next playmat's colour. The colour of the square presented on the tablet matched the colour of the playmat the child was supposed to go to. There were no instances of any child transitioning to the wrong area or refusing to transition. However, if that had occurred, a verbal prompt would have been repeated once, and if that had not resulted in the correct transition, the trial would have been terminated. Each trial consisted of 24 transitions leading to an experience of 8 rich, 8 moderate and 8 lean contexts, with the initial context as the final context. See Figure 1 for an illustration. Regardless of the context the child started from, it always experienced 24 transitions, 4 of each type (rich-moderate, rich-lean, moderate-rich, moderate-lean, lean-rich, lean-moderate). The

length of the video available on the tablet determined the reinforcer context. The order of the transitions was randomised across the trials.

Interobserver Agreement and Procedural Integrity

The data were collected by the second author using the TapTimer app throughout the study, in addition to two trained observers who attended and scored 100% of the sessions for each participant. The trained observers used a timer application on their phones to measure transition duration. Interobserver agreement (IOA) scores of the transition duration were calculated by dividing the shorter duration by the longer duration, converting the quotient to percentage, and averaging across trials within the session. Mary's average IOA score was 98%, with the low score at 97% and the high score at 99%. Kate's average IOA was 98%, with a low score of 97% and a high score of 99%. Ann's average IOA score was 99%, with a low score of 98% and a high score of 99%. Julie's average IOA was 99%, with a low score of 98% and a high score of 99%. John's average IOA score was 98%, with the low score at 98% and the high score at 99%. Tom's average IOA was 98%, with a low score of 98% and a high score of 99%. We implemented a procedure similar to that of Shvarts et al. (2020) to calculate procedural integrity. A checklist separated each session into four sections: MSWO was conducted before the session, playmats were in the correct locations, instructions were delivered, and the correct video was loaded into the TapTimer app. Any errors within those four sections of the checklist received zero points for those sections. The procedural integrity was calculated for each session by dividing the total number of sections executed correctly by the total number of all sections (errorless and delivered with errors) and multiplying that number by 100 to receive a percentage. Procedural integrity scored 96% on average across conditions and participants. The individual

average procedural integrity score measured 93% for Mary, 96% for Kate, 96% for Ann, 98% for Julie, 98% for John and 96% for Tom. Detailed data are available on request.

Results

The transition times between different reinforcer contexts in both phases of the Predictable Condition varied according to the upcoming context, but it did not happen in the Unpredictable Condition. Figure 2 shows transition time across transition types during the Predictable and Unpredictable Conditions. All children's transition times were longer when walking towards the leaner context in the Predictable Condition. Those results align with the existing research (Jessel et al., 2016; Langford et al., 2019; Perone & Courtney, 1992; Williams et al., 2011; Wood & Simon, 2023). Figure 2 shows the detailed differences in average transition times between children throughout the study. Transition times in phase 2 of the Predictable condition were reduced compared to phase 1 of the Predictable Condition and the Unpredictable Condition, except for Rich-Lean transitions, which increased in duration. In other words, Rich-Lean transitions were longer in phase 2 of the Predictable Condition than in phase 1 of the Predictable Condition. One possible explanation for that phenomenon is that when a lean reinforcer context is signalled, it can be found aversive and can generate extended pausing (Langford et al., 2019; Perone & Courtney, 1992; Williams et al., 2011; Wood & Simon, 2023).

In all children in phase 2 of the Predictable Condition, transition times between Moderate-Lean contexts were reduced by almost one-third compared to phase 1 of the Predictable Condition. For example, Kate's transition times reduced from average M=9.3s to average M=5.74s, see Figure 2. Moreover, transition times between Rich-Moderate contexts

were reduced for all children in phase 2 of the Predictable Condition compared with phase 1. For example, John's transition times reduced from average M=9.18s to average M=7.04s, see Figure 2.

Thus, our procedure showed that introducing moderate context can considerably reduce transition time when the upcoming context is signalled, as shown in Figure 2. The most substantial difference was observed between Rich-Lean (average M=12.48s) and Lean-Rich (average M=2.08s) transitions in phase 2 of the Predictable Condition compared with M=11.34s and M=3.6s respectively, in phase 1 of the Predictable Condition in all children. Those findings suggest that upcoming reinforcers that are predictable by mat colour served as signals, informing to what extent more could be obtained. Unlike Jessel et al. (2016), we did not observe meandering in children throughout the data collection. One potential reason for that is a very lean environment where the sessions occurred. The treatment room contained no furniture or toys, and blinds covered the windows. Moreover, parents agreed to restrict access to video watching at home, and thus, the only time children had access to their preferred activity was during the experimental sessions.

In the Unpredictable Condition, all children's average transition times were similar regardless of the upcoming reinforcer context. In this condition, we observed longer transition times from historically leaner to richer context compared with both phases of the Predictable Condition (see Figure 2).

However, the transition times from the richer to the leaner context in the Unpredictable Condition were shorter than those from the richer to the leaner context in phase 1 of the

Predictable Condition. This can be due to the lack of signal signalling to participants the richness of the upcoming reinforcer context.

Moderate-Lean transition times in phase 2 of the Predictable Condition were shorter than Moderate-Lean transitions in the Unpredictable Condition. Moreover, despite the longer transition times from leaner to richer context, the overall transition times were shorter than in phase 1 of the Predictable Condition. The longer transition times to historically richer context in Unpredictable Condition may be due to the lack of signals signalling the richness of the upcoming reinforcer context.

To examine the overall effects across sessions for each participant, Figure 2 shows that average transition times between different reinforcer contexts were more similar across all participants during the Unpredictable Condition than in both phases of the Predictable Condition. However, the differences were much smaller in phase 2 of the Predictable Condition compared with phase 1 of the Predictable Condition.

Discussion

In the present experiment, signalled transitions to the leaner reinforcer context were longer than those to the richer one. This aligns with previous findings from basic and applied studies (Wood &Simon, 2023; Jessel et al., 2016; Langford et al., 2019; Toegel & Perone, 2022). We observed a similar response pattern to those reported in the studies mentioned above; rich-lean transition times in the Predictable Condition (multiple schedule component) were longer than those in the Unpredictable Condition (mixed schedule component). This finding confirms the role of the discriminative stimuli signalling the worsening or the betterment of the conditions

in the Predictable Condition (multiple schedule component) on the transition duration in non-human and different human populations.

Similarly to the findings reported in Wood & Simon (2023), the moderate reinforcer context reduced the duration of signalled transitions of neurotypical children to the leaner reinforcer context by almost half. Transitioning of neurotypical children and children with ASD followed the same pattern. When the upcoming moderate reinforcer context was signalled in Rich-Moderate transitions, the transition time was shorter than in Rich-Lean transitions. This finding can improve procedures for children struggling with signalled transitions to a leaner context in their everyday lives. As suggested by Vitiello et al., (2012), transitions from circle time (if least preferred) to free play (if most preferred) can be accompanied by problem behaviour. This could be mitigated by adding a moderately preferred activity (such as a semi-structured group activity) between the most and least preferred ones.

Moreover, our findings show that longer signalled transitions to a leaner reinforcer context are typical for clinical and non-clinical populations, supporting their generality. To further extend the generality of our results, future basic research may investigate the effect of the moderate reinforcer context during signalled transitions in non-human subjects. The experimental control achieved in the operant laboratory and a more robust design could shed additional light on introducing moderate context during transitions in multiple schedule components. An interesting line of future research would be to elaborate on findings from Langford et al. (2019) by investigating if introducing a moderate reinforcer context would influence preference in multiple and mixed schedule components in pigeons during transitions.

The current study expands upon existing research examining transitions between different reinforcer contexts. Although choice under these conditions appears to be influenced by multiple factors, as reported by Langford et al. (2019) and Perone and Courtney (1992), our study aligns with the findings reported in Wood and Simon (2023), suggesting that behaviour is controlled by the upcoming reinforcer context, and not strengthened by the previous one. A possible explanation of those results is that in our study unlike in Langford et al. (2019), Perone and Courtney (1992), Williams et al. (2011), there were no transitions arranged between the same contexts, that is, rich-rich, moderate-moderate, or lean-lean transitions. In other words, the upcoming reinforcer context did not signal the repetition of the same conditions (i.e. Rich-Rich, Lean-Lean, Moderate-Moderate transitions) but rather the worsening or betterment of the upcoming conditions. This procedural difference was introduced to aid the applicability of the findings to real-life interventions in which children experience a vast range of transitions greatly exceeding those typically studied (i.e. rich-rich, rich-lean, lean-rich, lean-lean). Moreover, such procedural preparations allowed us to highlight the significance of the signalling effects of reinforcers during transitions between different reinforcer contexts. For example, transition times from Moderate to Rich context and Moderate to Lean contexts were shorter across all children in both phases of the Predictable Condition than in the Unpredictable Condition. Such results indicate the control of the signalling effects of the upcoming reinforcer context on the participant's behaviour instead of strengthening effects of the previous reinforcer context because, in that case, they should have been longer.

Another difference between transition preparations in non-human and human experiments is the lack of instructions in non-human studies (Perone & Courtney, 1992).

However, as reported by LaBrot et al., (2018) delivering adequate instructions promotes skills acquisition and proficiency in a wide range of individuals including children. This finding motivated us to include clear and effective instructions in our study to promote fast skill acquisition (transitions between different mats). The result of delivering clear and effective instructions allowed us to observe their very effect, which was fast skill acquisition by the participants. If the instructions had not been delivered, we could have observed slower skill acquisition, which could have negatively impacted the study results. We did not observe any additional effects of instructions delivery.

Similar effects were observed by Williams et al., (2011) (which replicated findings from non-humans from Perone and Courtney, (1992) in humans) who delivered instruction in Experiment 1 but not in Experiment 2. They did not consider instructions a source of control of participants' behaviour. Instead, Williams et al., (2011), reproduced the basic findings and concluded that pausing during transitions to the leaner reinforcer context was jointly controlled by the past and upcoming reinforcer context.

Due to practical reasons, we did not include transitions to the same reinforcer context as Jessel et al. (2016) and Perone and Courtney (1992) did. This experimental manipulation might be one of the reasons why our results are not identical to those reported in these studies. When children transitioned from the Rich reinforcer context in the Predictable Condition, they could only experience worse conditions, (Moderate or Lean contexts). Thus, the transition times in phases 1 and 2 of the Predictable Condition were shorter when transitioning to the better conditions and longer when transitioning to the worse conditions, confirming that the upcoming reinforcer context controlled their behaviour and not the previous reinforcer context. Moreover,

we did not observe joint control of the past reinforcer context and the stimuli signalling the upcoming reinforcer context, as Perone and Courtney (1992) and Williams et al. (2011) reported.

Perone and Courtney, (1992), observed shorter pauses before the Rich reinforcer context than before the Lean one, but they continued to be longer after the Rich reinforcer context than after the Lean reinforcer context. They suggested that the richness of the upcoming reinforcer context modulated the influence of the past reinforcer context. Moreover, in the presence of the signal before the Lean reinforcer context, the effect of the past reinforcer context was enhanced relative to its effect in the signal before the Rich reinforcer context. Perone and Courtney, (1992), concluded that pausing during transitions between different reinforcer contexts is jointly determined by two competing factors: past reinforcer context and signal correlated with upcoming reinforcer context. We did not observe this effect in our study, possibly due to the procedural differences between our study and Perone and Courtney (1992) and Williams et al. (2011) described above.

Additionally, our results from neurotypical children and those diagnosed with ASD (Wood & Simon, 2023) bridge the gap between basic and applied behaviour analysis by applying the signalling perspective to a relevant context for clinicians. As elaborated throughout this paper, the signalling perspective is a more plausible explanation of obtained results because transition time can be accounted for by the stimuli associated with the upcoming reinforcer context and not the previous one. Thus, reinforcers and events in close correlation with them might not strengthen the response they follow but rather guide behaviour to where and how more of them can be obtained. Those results add to the current literature (Baum, 2012, 2016, 2018b; Cowie, 2020; Cowie et al., 2017; Simon et al., 2020), suggesting that signalling properties of

reinforcers explain behaviour in a more straightforward way than the strengthening perspective proposed by Skinner (1938).

Our study would have benefited from improved inclusion criteria. Recruiting participants with other preferred objects than video watching would have made the results more interesting. However, it was not possible in the current study because the MSWO ranks results showed that all participants chose video watching as 1st, 2nd, 3rd, 4th and even 5th (Ann) preferred item out of the array of six items (e.g. small toys, glitter glue and paper, stickers). In other words, video watching was ranked 1st, 2nd, 3rd, and 4th in the hierarchy of preferred objects for five out of six children.

One additional limitation is related to the number of conditions. In the present study, the Predictable Condition was repeated, and the Unpredictable Condition was not. Although we observed responding according to the schedule requirements and in line with the previous literature on Unpredictable Condition (mixed schedule), we may have learned more about the phenomena if more data had been collected.

In conclusion, our study adds to the existing literature on several levels. It provides further evidence that the signalling perspective is a highly plausible explanation of behaviour during transitions. It is also an example of a translational study that incorporated strict fidelity measures to allow further basic and applied replications. The obtained results are beneficial and informative for applied behaviour analysts because they confirmed that a moderate reinforcer context could substantially reduce transition time to a leaner context during signalled transitions. This finding has direct clinical implications and can improve procedures to teach successful transitions in those populations. Moreover, it supports the increasing number of studies that

report that an advance notice procedure (Brewer et al., 2014; Toegel & Perone, 2022) is ineffective in reducing rich-lean transition times.

Abbreviations

ASD- Autism Spectrum Disorder, FI- Fixed Interval, FR- Fixed Ratio, MSWO- Multiple Stimulus Without Replacement Assessment, IOA-Interobserver Agreement, SD-Discriminative Stimuli, M-Mean.

Declarations

Ethics approval and consent to participate, consent for publication, availability of data and material, and competing interests

All procedures performed in this study involving human participants were by the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. The study was conducted under Approval 282790, granted by the Regional Committee for Medical and Health Research Ethics; Approval 931299, granted by the National Centre for Research Data and Approval RITM01945551, granted by the University Faculty Ethics Committee. The study was conducted in partial fulfilment of the second author's PhD degree. Written informed consent was obtained from the parents. Parents signed informed consent regarding publishing their children's data.

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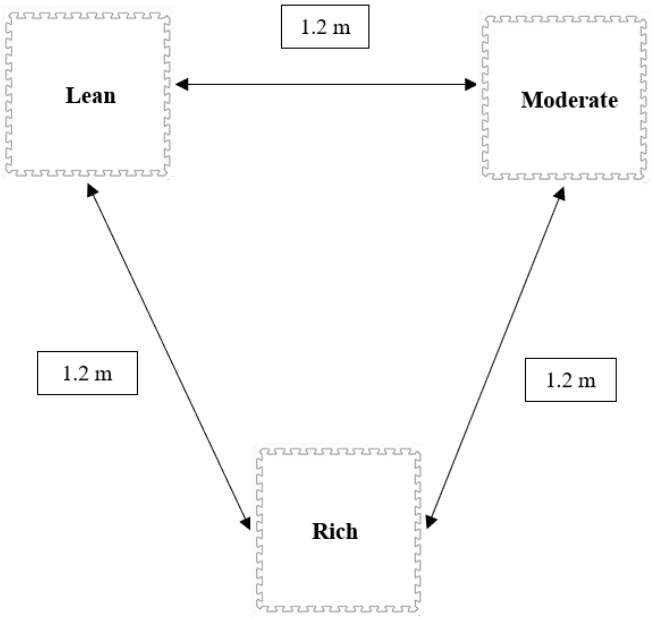
Figure 1

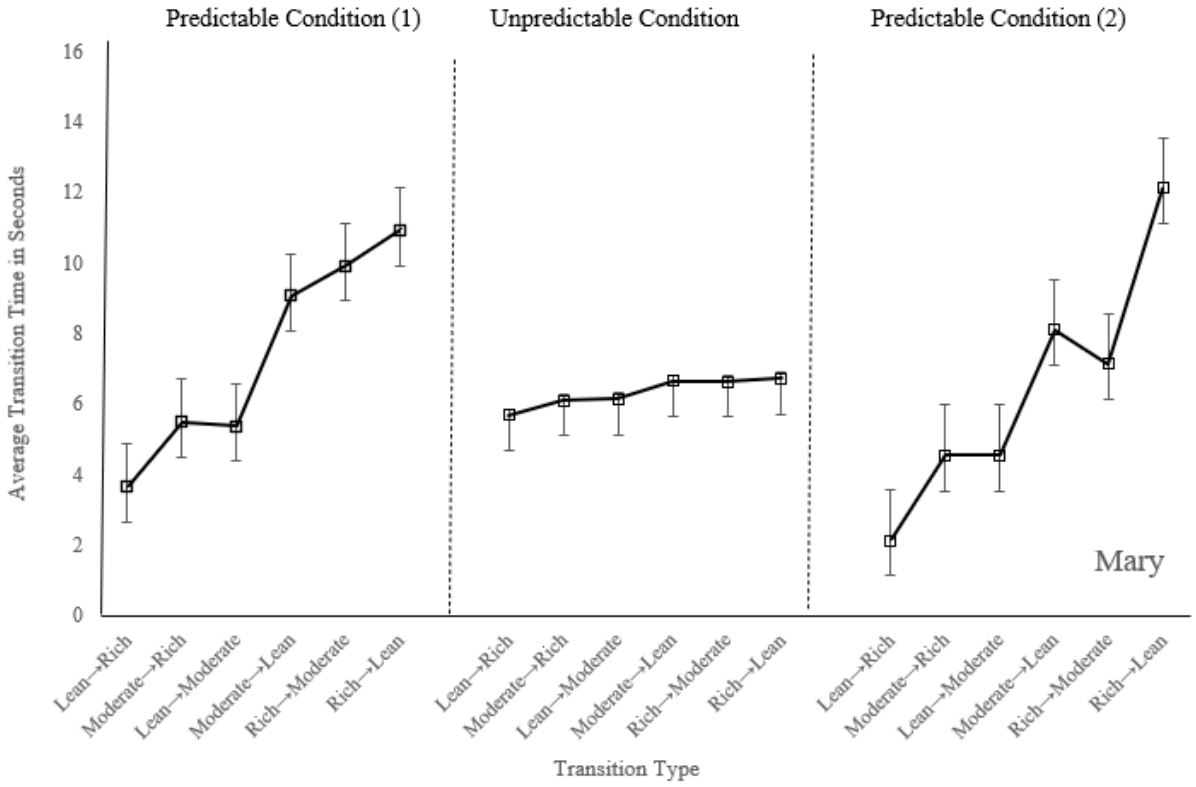
A diagram of the setting used in the Predictable and the Unpredictable Condition.

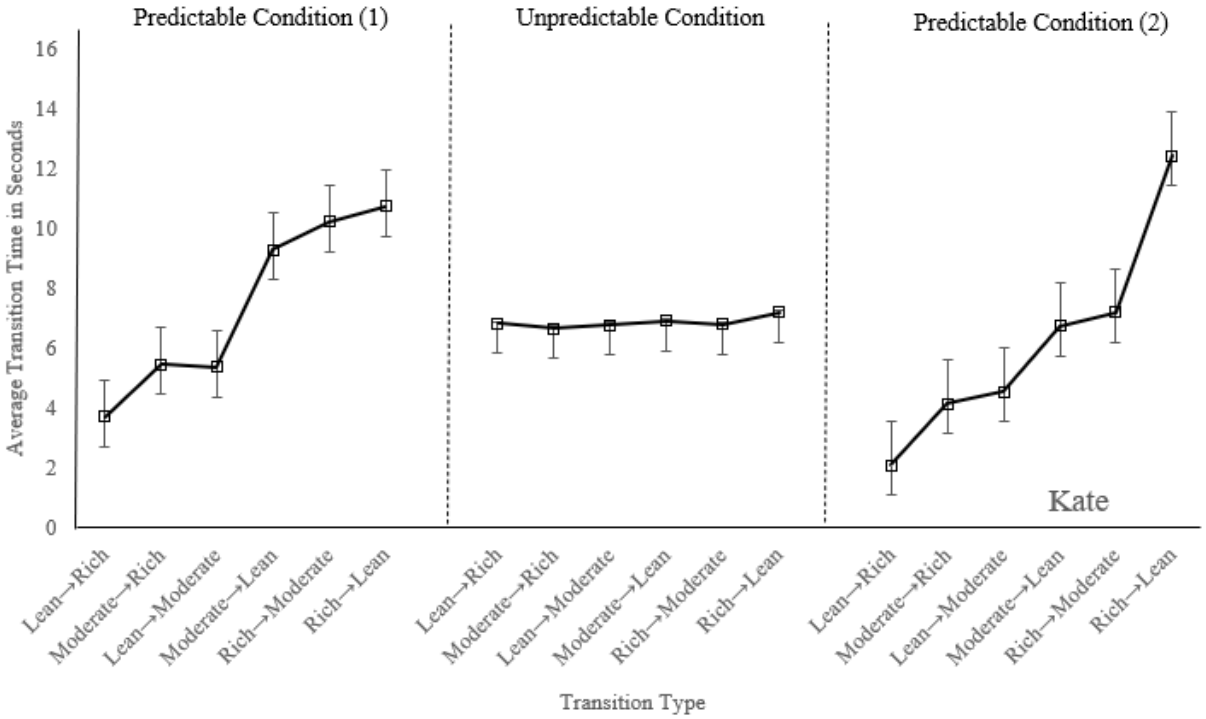


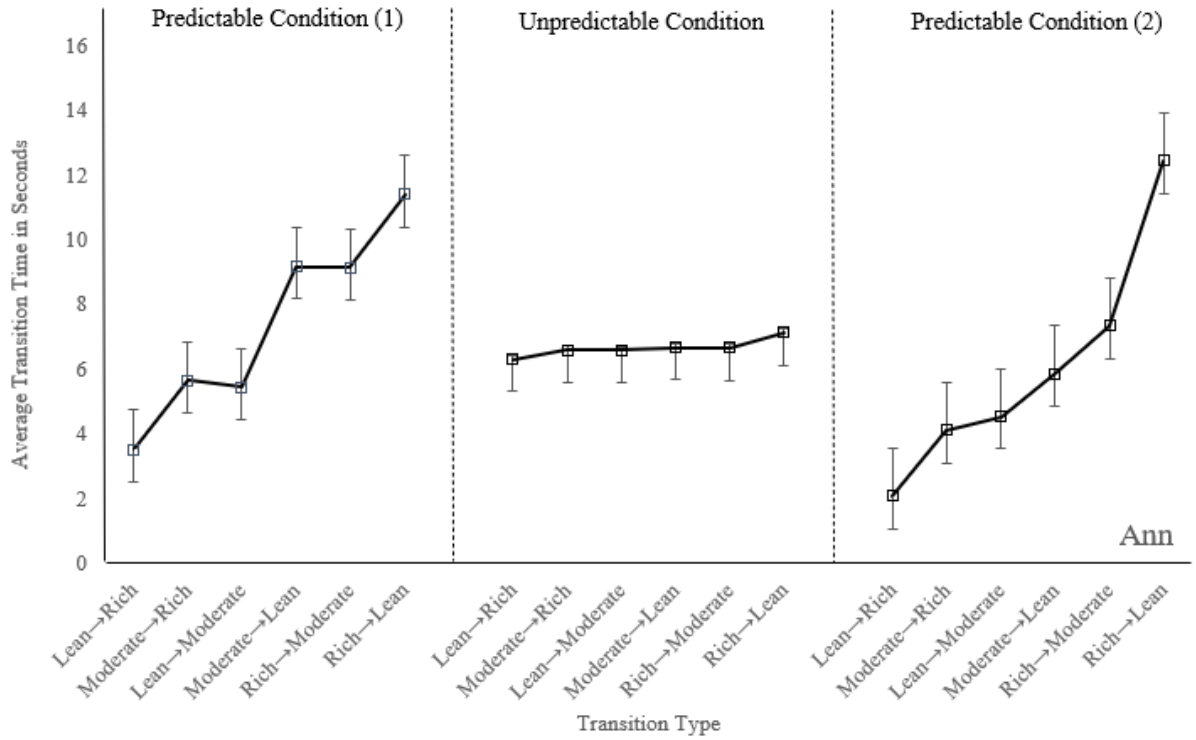
Note. The arrows represent the distance between the mats; each mat represents a specific reinforcer context (rich, moderate, or lean) in the Predictable Condition. In the Unpredictable Condition, each mat could represent each context. The mats were always placed in the shape of a triangle. The position of each mat varied between the trails.

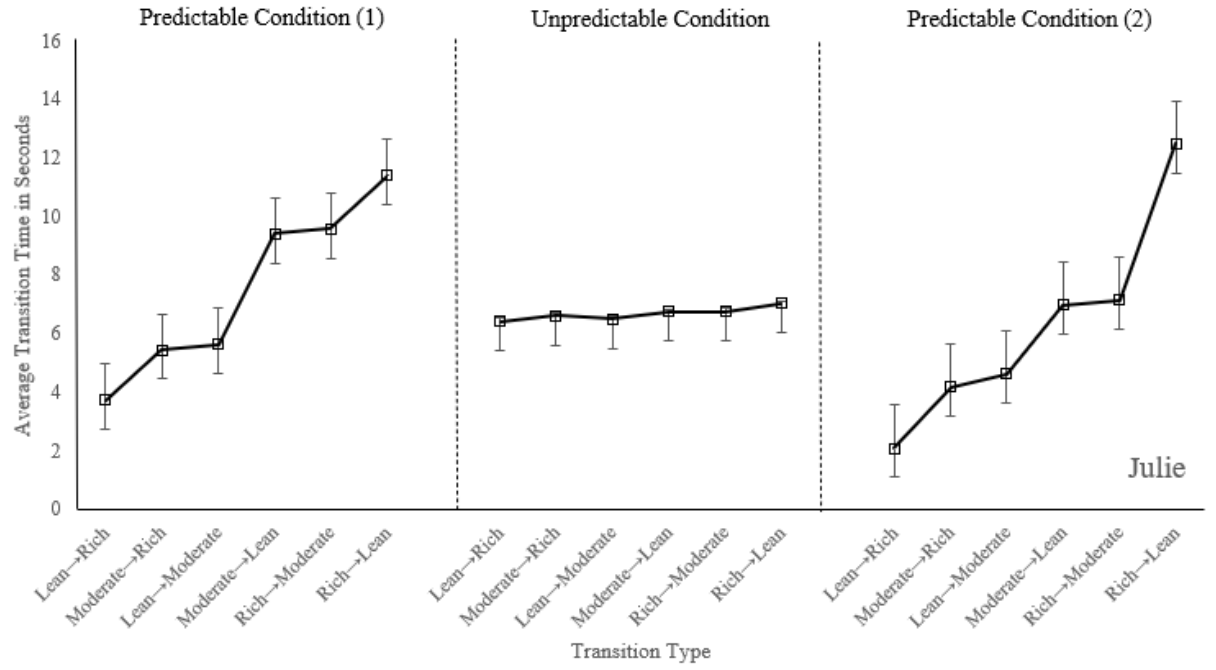
Figure 2

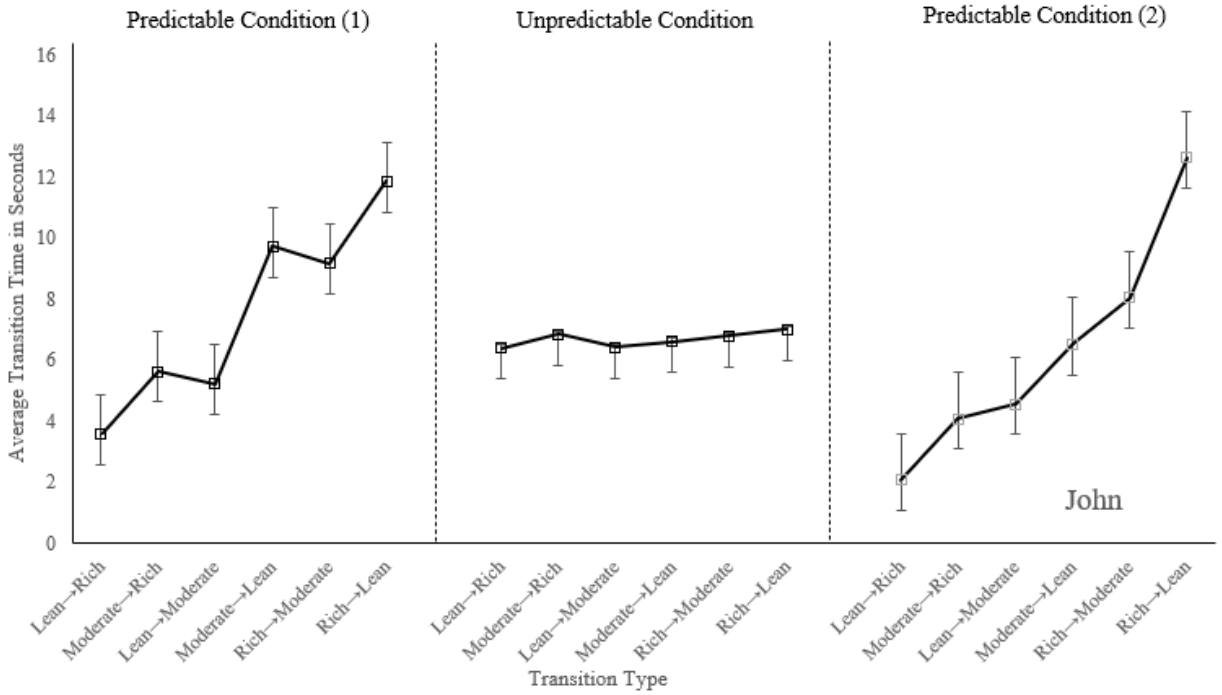
Average transition times across transition type and standard error bars for each participant across the Predictable and Unpredictable Conditions.

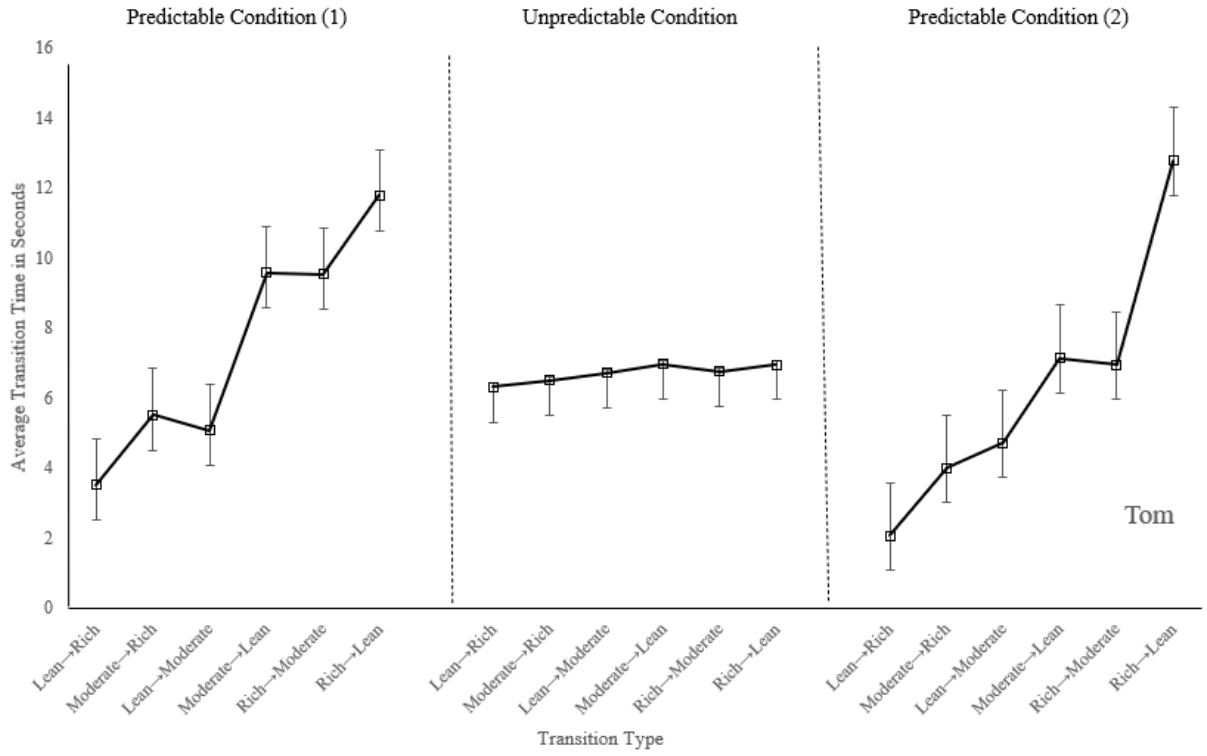



Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
Kate
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type


Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
Ann
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type


Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
Julie
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type


Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
John
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type


Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type
Tom