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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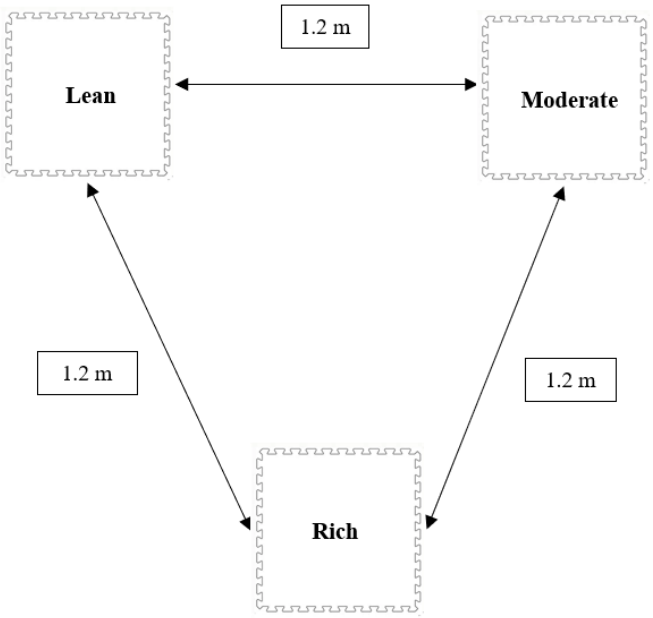
Figure 1

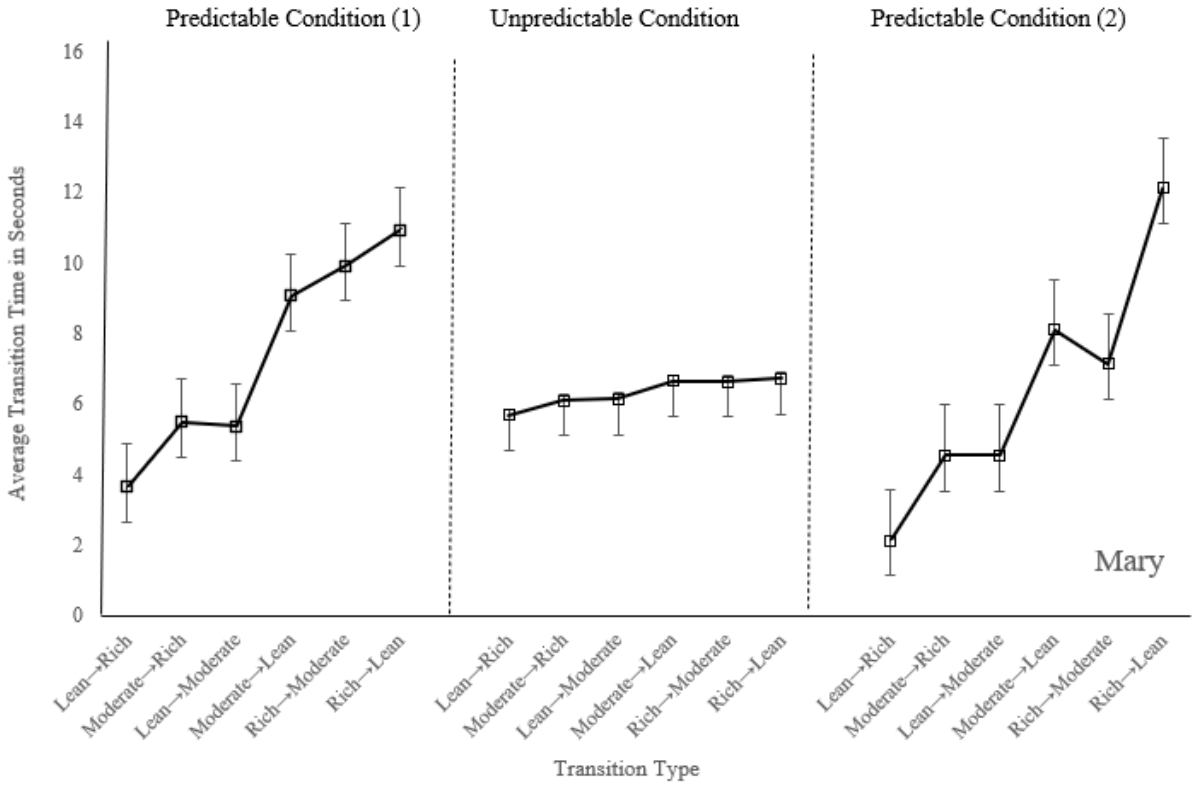
A diagram of the setting used in the Predictable and the Unpredictable Condition.

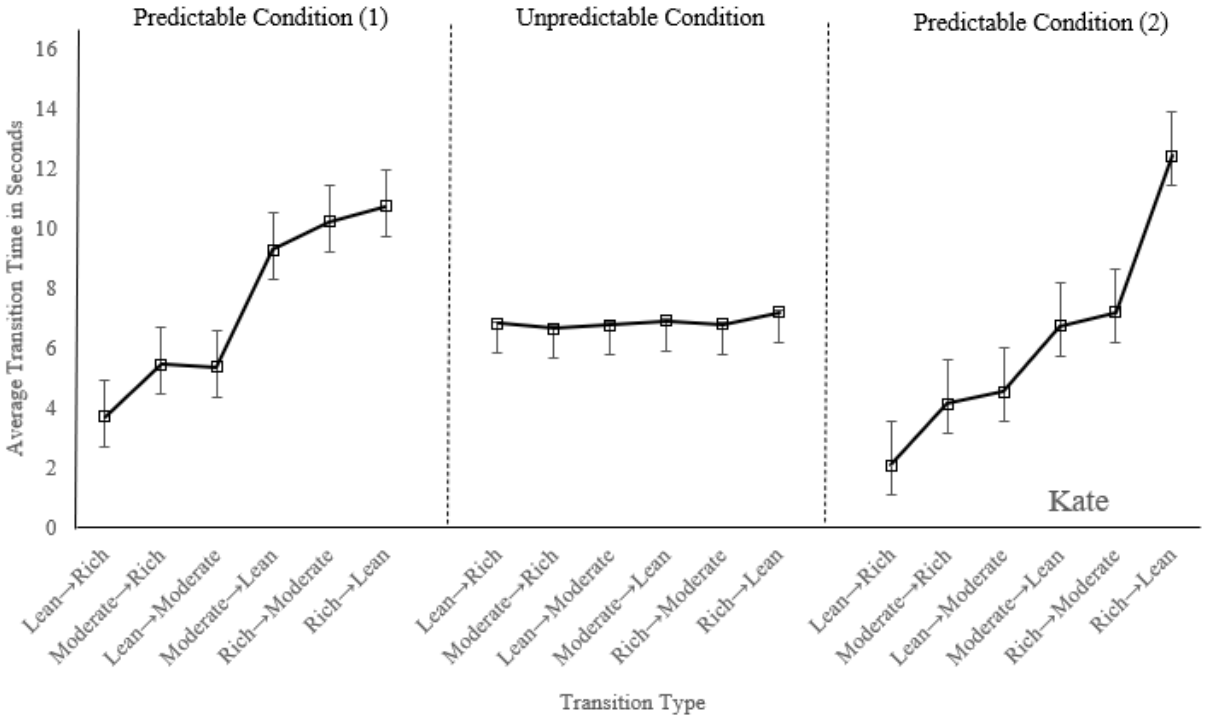


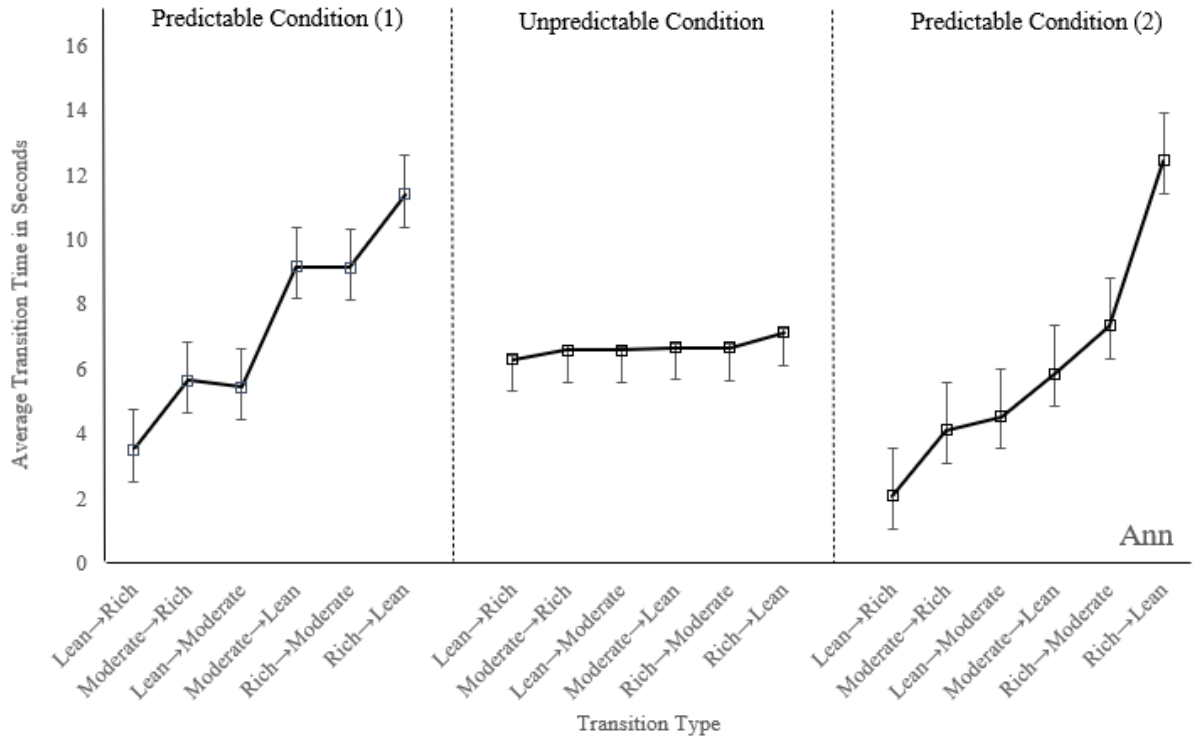
Note. The arrows represent the distance between the mats; each mat represents a specific reinforcer context (rich, moderate, or lean) in the Predictable Condition. In the Unpredictable Condition, each mat could represent each context. The mats were always placed in the shape of a triangle. The position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

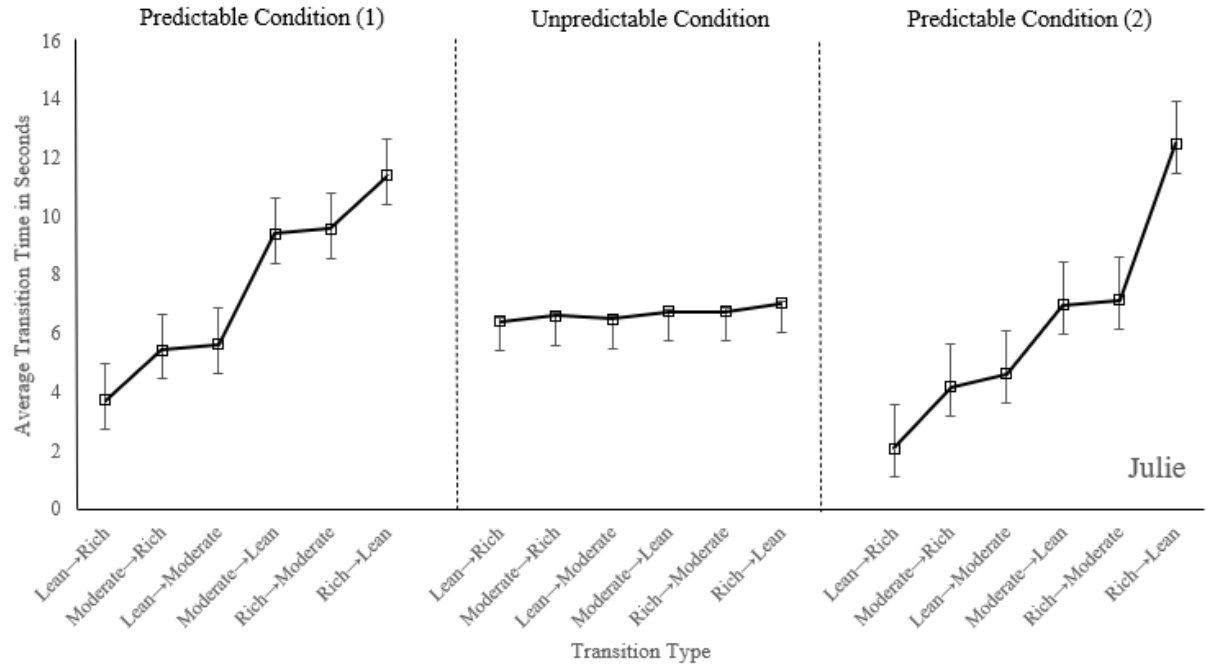
Figure 2

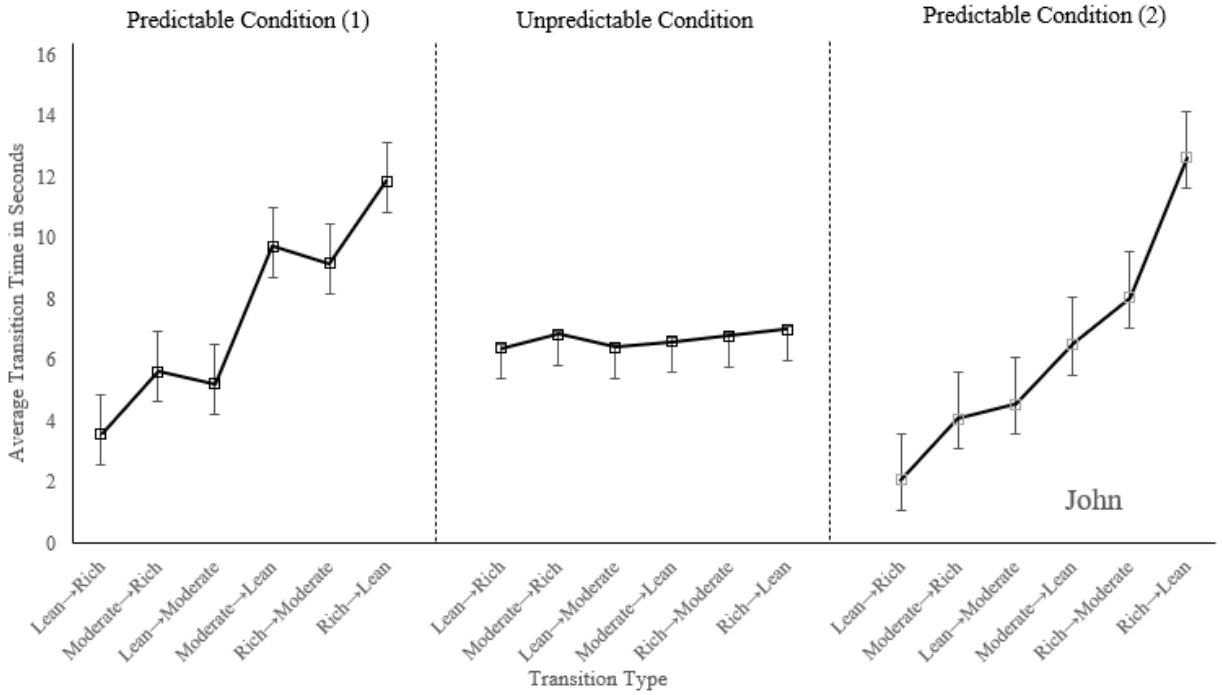
Average transition times across transition type and standard error bars for each participant across the Predictable and Unpredictable Conditions.

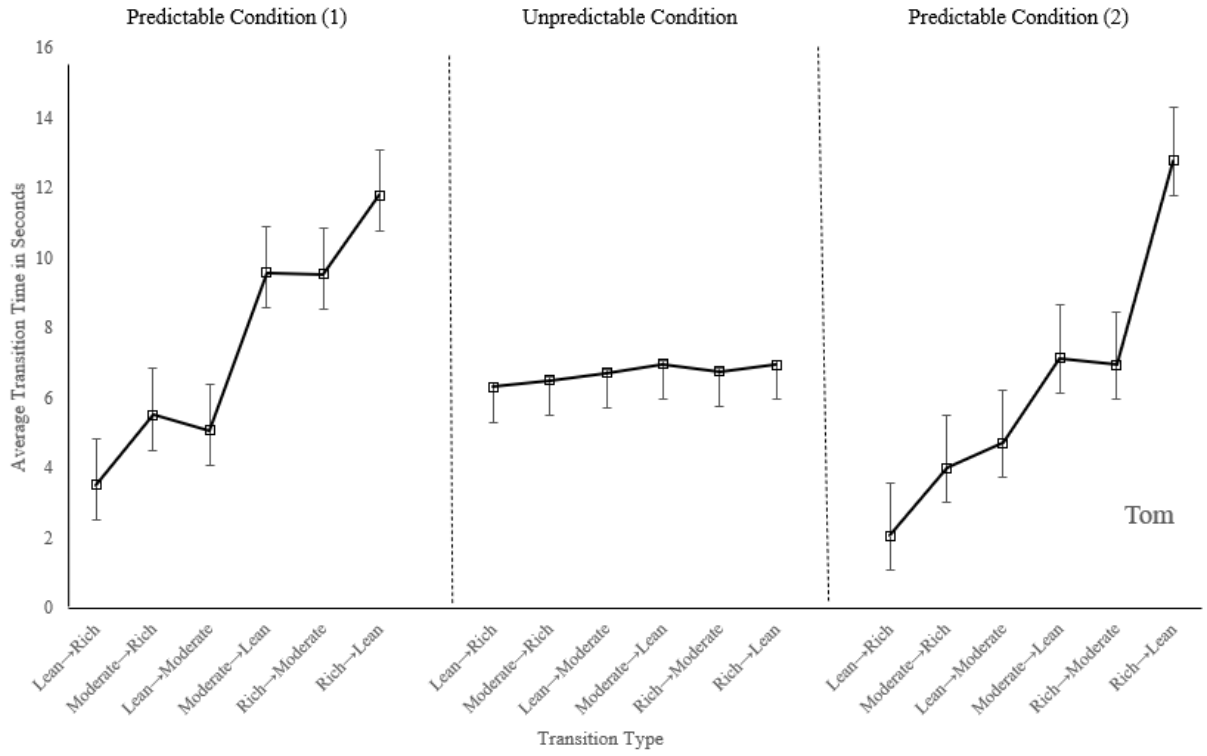



Predictable Condition (1)
Unpredictable Condition
Predictable Condition (2)
Average Transition Time in Seconds
0
2
4
6
8
10
12
14
16
Kate
Lean→Rich
Moderate→Rich
Lean→Moderate
Moderate→Lean
Rich→Moderate
Rich→Lean
Transition Type


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