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Differences and Correlations between Instruction Patterns in Consecutive, Selective Reaction-Time Tests Administered to Early Childhood Participants

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Abstract

This research considered the effect of differences between instruction patterns in consecutive, selective reaction-time tests administered to early childhood participants. Participants included 62 young male children (mean age 5.3 ± 0.6 years, mean height 107.4 ± 5.5 cm, mean mass 17.9 ± 2.2 kg). Starting from a standing position, each participant rapidly moved eight times on a sheet—either left, right, forward, backward, or diagonal—in accordance with the given target. Five different combinations were used; each combination required participants to move in each of the eight possible directions once, including the four diagonal directions. On each pattern, the total times for all participants were added to yield a consecutive, selective reaction time for that pattern. Single-factor dispersion analysis results did not indicate a statistically significant difference in reaction times between the test patterns (the level of significance was determined as 0.05). Furthermore, a greater-than-medium correlation between the five patterns with regard to their total consecutive, selective reaction-times was observed. Consequently, while no large difference was demonstrated between patterns, a relatively high correlation was observed between patterns on consecutive, selective reaction-time tests administered to young children.

Keywords

Agility, Male Children, Reaction-Time

1. Introduction

During infant development, neurological functions grow dramatically and suitable, stimulating exercise is important to encourage this growth. Neurological functions are closely linked to coordination and regulatory skills, of which agility is an important component. Agility is associated with infants' developing the ability to efficiently shift their center of gravity. Therefore, it is essential to formulate tests that can reliably evaluate young children's agility development.

Continuous jump over tests, simple reaction-time tests and side-step tests are typically used to evaluate children's agility during early childhood (Sugihara et al., 2006; Roth et al., 2010; Donath et al., 2014; Miyaguchi & Demura, 2012). These tests examine agility through the number of movements completed or through simple movement speed. However, during early childhood, daily living involves recognizing danger, moving quickly to avoid it, and repeatedly and accurately altering one's direction of movement during play. Hence, consecutive and selective reaction-time observations, and not only speed assessments, are essential to evaluate young children's agility.

In recent years, consecutive and selective reaction-time tests that use on-screen directions have been developed for adults (Uchida et al., 2013). It can be reasonably presumed that these tests are appropriately applicable to young children as well. For instance, young children may have slower consecutive, selective reaction times than older children, who have more developed neurological functions, and we may be able to identify an age-related change pattern. Existing research has used instruction patterns having five different directions to avoid the possibility of participants remembering and predicting instructions on tests that repeat the same instruction sets in multiple cycles. The evaluation variable is the average reaction time for each pattern (Uchida et al., 2013). Young children, however, differ from adults because of their undeveloped muscular and neurological functions; thus, the required movements' order may substantially affect reaction times. This tendency may, consequently, affect the relationship between instruction patterns. When the similarity between patterns is low, the possibility of differences in reaction times between patterns must be considered in tests of young children as a different evaluation method may be required. It was hypothesized that, even if a set pattern is adequate enough to evaluate the tests, the difficulty level of the test changes according to a selected pattern and varies with the measurement values.

For practical purposes, it is necessary to examine the differences in the test patterns. It is possible that the difficulty level of the test differs by patterns.

This research considered the effect of differences between instruction patterns in consecutive and selective reaction-time tests administered to early childhood participants.

2. Methods

1) Participants

The participants included 62 healthy, male children, who were aged between 4 and 6 years (mean age 5.3 ± 0.6 years, mean height 107.4 ± 5.5 cm, mean mass 17.9 ± 2.2 kg), and are residents of medium-sized cities in Japan. The details, methodology, and risks of the tests were explained in advance to the participants' guardians and the principal of the school where they attended kindergarten, and permission for their participation was obtained.

2) Experiment equipment and methods

In this study, nine step seats (belonging to the step measuring system, Takei Scientific Instruments Co., Ltd., Japan) were used as the successive choice reaction test devices in this study. If the stimulus presentation pattern is the same among all the trials, then the subjects might remember the reaction directions (Uchida et al., 2013). Therefore, to comply with this requirement, the five rapid instruction patterns used in a report by Uchida et al. (2013) were used in this research as well.

Figure 1 shows the placement of the sheet on which the participants stood. Participants followed each instruction pattern by moving rapidly to the corresponding cells in order (**Figure 1**).

As a different pattern is used for each test cycle, it is extremely difficult to predict directions prematurely. Eight rapid movement possibilities (left, right, forward, back, or diagonally in any of the four possible directions) were used in combinations that compelled participants to move once in each of the eight directions; the patterns were constructed to ensure that all movements would be to adjacent cells only (Uchida et al., 2013). The chosen tempo was 20 bpm.

Table 1 shows the five instruction patterns used in this research. Pattern A, for example, led the participant from the center cell to the upper right, and subsequently to the lower right, the center, the upper left, the center, the right, the bottom, and back to the center (Uchida et al., 2013).

Participants stood on the center cell of sheets. They observed a laptop computer set in front of them. They observed a laptop computer set in front of them. The laptop played a movie that consecutively showed the directions in which the participants were expected to move. The participants followed these instructions and moved to the corresponding cell (Uchida et al., 2013).

The time from the display of each instruction to each participant's arrival at the specified area on the sheet was added to yield a consecutive, selective reaction time for each pattern. One trial test was performed for each pattern, respectively.

Figure 1. Arrangement of step seats.

Table 1. Pattern of stimulus presentation (Uchida et al., 2013).

	1	2	3	4	5	6	7	8
Pattern A	diagonal-forward right	backward	diagonal-forward left	left	diagonal-backward right	right	diagonal-backward left	forward
Pattern B	diagonal-backward left	forward	diagonal-backward right	right	diagonal-forward left	left	diagonal-forward right	backward
Pattern C	forward	diagonal-backward left	right	diagonal-forward right	left	diagonal-backward right	backward	diagonal-forward left
Pattern D	backward	diagonal-forward right	left	diagonal-backward left	right	diagonal-forward left	forward	diagonal-backward right
Pattern E	right	diagonal-backward left	forward	diagonal-forward right	left	diagonal-backward right	backward	diagonal-forward left

3) Data analysis

Single-factor dispersion analysis was used to evaluate the differences between the average reaction times for the patterns. Pearson's correlation coefficient was calculated to examine the correlation between each pattern's reaction times. The level of significance was determined as 0.05.

3. Results

As **Table 2** indicates, the single-factor dispersion analysis did not demonstrate a statistically significant difference in reaction times between the test patterns.

Table 3 indicates the correlations between each test pattern's reaction times. A greater-than-medium correlation was observed between each test pattern's reaction times.

4. Discussion

Reaction time is generally defined as the smallest observed delay in intentional response to a given stimulus (Chocholle, 1940). In contrast to full-body selective reaction-time tests, in which the participant stands still and waits for a rapid instruction, this research used a series of consecutive instructions issued continuously, following which the participants had to make a series of eight consecutive movements (Uchida et al., 2013). Furthermore, consecutive, selective reaction-time tests involve the dual challenge of responding to a visual signal and determining the direction of movement. Research has indicated that, when young children are presented with dual challenges, the demand for attention to the primary challenge increases as its difficulty level increases; correspondingly, performance on the secondary challenge decreases since attention toward it decreases (Shumway-Cook et al., 1997; Kerr et al., 1985; Lajoie et al., 1996).

Table 2. Analysis of differences in reaction times between instruction patterns.

	Mean	SD	F-value	*p*-value
Pattern A	11.80	1.89	1.863	0.118
Pattern B	11.65	1.81		
Pattern C	12.03	1.99		
Pattern D	12.14	2.14		
Pattern E	11.95	2.27		

Table 3. Correlations between each test pattern's reaction times.

	Pattern A	Pattern B	Pattern C	Pattern D	Pattern E
Pattern A					
Pattern B	0.72*				
Pattern C	0.74*	0.67*			
Pattern D	0.69*	0.69*	0.66*		
Pattern E	0.75*	0.63*	0.68*	0.76*	

*$p < 0.05$.

The consecutive, selective reaction-time tests utilized in this research used a slow 20 bpm tempo for issuing rapid instructions. However, its difficulty level was high for young children, unlike for adults who have developed functional systems, since both simple forward and left-right directions were used along with backward movements. Differences in reaction times were expected owing to changes in the order of movements instructed. However, the analysis did not indicate a significant difference in reaction times between the test patterns. Research has shown that with an increase in participants' age, reaction time to visual signals decreases (Miyaguchi & Demura, 2012). Moreover, observed selective reaction times in rock-paper-scissors tests administered to young children did not indicate a significant generational difference when participants were asked to match the displayed picture. However, when participants were asked to try to "win" by choosing an option that differed from the display, a significant generational difference was observed and participants became faster with age (Yokoya & Noguchi, 2015). The five- to six-year-old children examined in this research had developed neurological functions. Therefore, it is possible that the participants could complete the challenge within the stipulated time even though the instructed movements were difficult and their order varied.

A greater-than-medium correlation was observed between each test pattern's reaction times. As these tests were consecutive and rapid, participants were required to stabilize their posture (in preparation for the next command) while responding to rapidly presented stimuli. Young children aged five or older can respond to stimuli even if the order of movement commands vary; hence, it is inferred that a relatively high correlation in reaction times has been obtained between test patterns.

5. Conclusion

No significant differences were observed in selective reaction-time tests administered to young children; however, a relatively high correlation between test patterns was observed. It is hypothesized that for evaluating the agility of early childhood a successive choice reaction test with any pattern is valid.

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