様　式　Ｃ－１９、Ｆ－１９－１、Ｚ－１９　（共通）

科学研究費助成事業　　研究成果報告書

令和　５ 年　 ５ 月 ３１ 日現在

機関番号：１２５０１
研究種目：若手研究
研究期間：2020～2022
課題番号：２０Ｋ２０１４２

研究課題名（和文）Leap before you look: Choice of impulsive strategies for reward maximisation

研究課題名（英文）Leap before you look: Choice of impulsive strategies for reward maximisation

研究代表者
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交付決定額（研究期間全体）：（直接経費）　　3,200,000円

研究成果の概要（和文）：本研究の目的は，衝動的な行動に繋がる要因や状況を特定することで，衝動性の動物モデルの作成することである。それを達成するため，種間比較に使用できる，行動指標を使った衝動性課題の確立，および衝動性と空間的注意，メタ認知，記憶の関連の検討をおこなった。本研究で得られた結果から，行動課題と質問紙で測定された衝動性に乖離があること，衝動性関連の特性にはヒトとハトに類似点と相違点が両方あること，などが分かった。これらの結果は，適切な衝動性課題の提案や衝動性と心理特性の関連の更なる検討など，今後の衝動性研究の方向性を示唆する。

研究成果の学術的意義や社会的意義
Creation of an animal model of impulsivity will not only be a major contribution to add to the long history of impulsivity research, but also has limitless applications including risky road behaviours, mental disorders such as ADHD, substance addiction, academic problems, and anti-social behaviours.

研究成果の概要（英文）：The aim of the proposed research project was to create an animal model of impulsivity by identifying the factors and contexts responsible for impulsive behaviours. This was achieved mainly by designing behavioural impulsivity tests that can be used across species and identifying the links between impulsivity and spatial attention, metacognition and memory. The results from the studies in the project include discrepancy in the scores of behavioural task and traditional questionnaire in humans and highlights similarities and differences in impulsivity-related attributes in pigeons and humans. These results suggest future directions for impulsivity research, especially in the methods of obtaining appropriate impulsivity measures and in further investigating the relation between impulsivity and other psychological attributes.

研究分野：Comparative cognition

キーワード：impulsivity

１．研究開始当初の背景

Despite the assumptions that impulsive behaviours are disadvantageous for animals, impulsive strategies can be useful under some contexts. When you encounter a difficult problem, it may be a better idea to respond quickly rather than to waste time pondering on it. The best solution for all cases would be to have the flexibility to select the appropriate strategy to use under each context. The natural environment is changing all the time and, especially for animals in the wild, this flexibility may be the key to their survival. Therefore, even if there are individual or species tendencies, there should be a variation in the amount of impulsive behaviours demonstrated by animals depending on the nature and difficulty of a problem. The main objective of the proposed project is to create an animal model of impulsivity by identifying factors and contexts responsible for impulsive behaviours. More specifically, the proposed project aims to investigate whether there is a difference in frequency of exhibited impulsive choice in tasks that vary in nature and difficulty.

Impulsive behaviour refers to when one chooses small sooner reward over large later reward. Because value of reward decreases over time, one's preference for large reward will switch to small reward at some point when the delivery of the large reward is delayed. Animals with high impulsivity show rapid discounting of rewards that are distant in time.

The majority of studies on impulsivity, so far, has been interested in the impulsivity level for each individual or species. For example, individual level of impulsivity was measured to show that humans with high ratings are more likely to be associated with drug-addiction, drinking problems, and smoking (e.g., Bickel et al., 1999). High impulsivity is also known to be associated with low academic achievement (Merrell & Tymms, 2001) and risk-taking behaviours (Lejuez et al., 2002). Furthermore, impulsivity is also an indication of some mental disorders such as attention deficit hyperactive disorder (ADHD). Impulsivity may also have long-term effects as suggested in the famous marshmallow test, which found that children who could refrain from reaching out for snacks showed better social and academic performance during adolescence than those who made the impulsive choice of immediate consumption (Mischel, 1966; 1974). These observations work under the assumption that individuals have relatively stable level of impulsivity over time and situations. In the other words, there exist impulsive people and non-impulsive people.

In the cases of nonhuman animals, impulsivity is usually studied in terms of self-control between species. Self-control is the ability to inhibit immediate responses and is usually considered to be inversely related to impulsivity. While pigeons and rats are considered to have low self-control, as they can wait only for matter of seconds for food, bonobo and chimpanzees are considered to have much higher self-control, being able to tolerate longer waiting times (MacLean et al., 2014; Stevens, 2014). There are three hypotheses for such species differences. The body size hypothesis, the cognitive ability hypothesis, and the social brain hypothesis state that high self-control is associated with animals with larger body size, animals with high levels of cognition, and animals that live in complex social groups, respectively. Similar to the situation in human impulsivity research, many studies assume that each species have relatively stable level of self-control over time and situations

Despite the assumptions on the stable nature of impulsivity, the ideal solution to problems would be to flexibly select impulsive and non-impulsive strategies that is suited for a given situation.

２．研究の目的

The aim of the proposed research project was to create an animal model of impulsivity by identifying factors and contexts responsible for impulsive behaviours. More specifically, it aimed investigate whether there is a difference in frequency of exhibited impulsive choice in tasks that vary in nature and difficulty.

The most unique aspect of the project is that it treats impulsivity as a property that varies within an individual depending on the context. By creating an animal model that acknowledges this variability, we will be able to identify particular situations in which human and animals behave impulsively. This would not only be a major contribution to add to the long history of impulsivity research, but also has limitless applications for the real-world. For example, impulsivity is often associated with risky driving on the road. The impulsivity model can help identify what it is about driving that makes people choose risky behaviours, such as speeding and sudden change of direction, and suggest ways to manage

them. Furthermore, because impulsivity is known to be related to a wide range of cognitive and behavioural problems, the impulsivity model may also provide clues for managing issues including ADHD, substance addiction, academic problems, and anti-social behaviours.

３．研究の方法

To study impulsivity and related attributes in multiple species, the project involved four main approaches — establishing a method to test impulsivity across species, investigating relation of impulsivity and other cognitive attributes, investigating spatial attention in pigeons, and designing memory-based tests for future cognitive experiments.

(1) Measuring individual differences in impulsivity

① Behavioural impulsivity task for pigeons and humans

The traditional impulsivity test (Mazur, 1987) involve a choice between small sooner reward and large later reward. In the case for non-human subjects, choosing the former will result in decreasing the delay for the latter, and choosing the latter will result in increase in this delay. The point at which the subjects value the two choices to be equal shows the impulsivity level for the subject. Using this method, I have previously shown that pigeons show individual differences on this measure of impulsivity. The traditional questionnaire to measure impulsivity in humans may be problematic for the purpose of species comparison because it uses language and it involves imagined situation rather than the actual behaviour. To solve these issues, I designed a novel human impulsivity task that parallels the task used in pigeons. Human subjects were presented with the computer "battle game", where they needed to attack the enemy by choosing a low-damage weapon that could be used with short wait and a high-damage weapon that required a longer waiting time. The scores obtained from this game was further used for (2) ①. In addition, the participants were asked to answer a typical impulsivity questionnaire (BIS-11, Patton, et al., 1995).

② Reported personality and behavioural responses in cats

For assessment of personality in companion animals, various questionnaires for owners have been developed. I translated the items on Domestic Cat Personality Inventory (Bennett et al., 2017) for comparison with behavioural data on how cats responded to moving stimuli on a touch screen.

(2) Impulsivity and its relation to other attributes

① Impulsivity and spatial attention in pigeons and humans

I have previously found a relation between impulsivity and spatial attention in pigeons. To investigate if such relation is also found in humans, I looked for a correlation between the individual's impulsivity data from (1)① and his/her performance on a spatial attention task.

② Impulsivity and metacognition

Because impulsivity and metacognition are closely associated, I investigated the metacognitive behaviour of pigeons during a visual discrimination task. During the choice phase, where the pigeons were presented with a correct and an incorrect stimuli, they were presented with an additional stimulus, which allowed for termination of the trial.

(3) Spatial attention to movement in pigeons

Because pigeons' behaviour is, as was seen in the results of (2)②, strongly controlled by the physical characteristics of the visual stimuli used in a task, I investigated how their attention is directed on a screen in response to moving cues in social and non-social contexts.

① Sensitivity to non-social cues

Pigeons were required to discriminate the movements of two circles on the touchscreen. Their sensitivity to movement was measured by adjusting the timing of the initiation of the movements.

② Sensitivity to social cues

Pigeons were required to respond to the target stimulus that appeared on the touchscreen shortly after the presentation of a photograph of a conspecific's head. On some trials, the target appeared in line with the conspecific's gaze, and on the rest of the trials it appeared on the other side of the conspecific's gaze.

(4) Designing memory-based tests for pigeons

It is often suggested that the ability to plan for the future is closely linked the ability to remember the past. Impulsivity is a measure of temporal discounting of a future reward,

and, therefore, it is reasonable to consider its relation to memory for past events or items. As a fundamental step to the prospects of investigating this relation, two types of memory tasks were evaluated.

① Visual short term memory task

As a first step towards designing a test for visual short term memory, pigeons were trained on a same/different discrimination involving multiple items on a screen.

② Source memory

Because there has been no standardised operant test for episodic-like memory for nonhuman animals, I adopted a source memory task (Basile & Hampton, 2017), which was originally designed for rhesus monkeys. After presentation of two items in succession, on different backgrounds, the pigeons were required to choose the item previously presented on the specified background.

4．研究成果

(1) Measuring individual differences in impulsivity

① Behavioural impulsivity task for pigeons and humans

The "impulsivity game" task was successful in recording low-reward-preference scores that showed large individual variation. These scores did not show a positive correlation with BIS-11 scores (Fig. 1), suggesting that the behavioural task and the questionnaire are measuring different aspects of impulsivity. The results from this study emphasises the importance of using similar tasks for species to be compared.

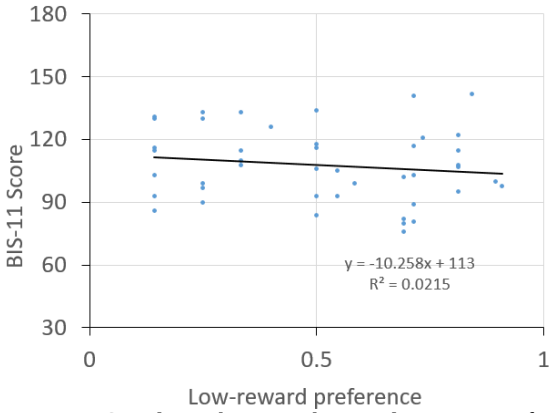

Fig. 1. Correlation between the impulsivity scores from the game and BIS-11

② Reported personality and behavioural responses in cats

It was found that the cats' looking behaviour towards moving stimuli on the screen negatively correlated with the owners' rating of playfulness on a personality questionnaire. This discrepancy raises the possibility that impulsivity of cats as rated by human owners may also be different from impulsivity assessed in a behavioural task. The results from this study was presented at a national conference in 2020.

(2) Impulsivity and its relation to other attributes

① Impulsivity and spatial attention in pigeons and humans

The above low-reward-preference scores were plotted against performance on a spatial attention task. Unlike pigeons, there was no relation between the two measures. This leads to the possibilities that such relation is specific to pigeons or is missing in humans. Further study of this pattern in the animal kingdom will provide insights on the evolutionary history and the functions of impulsivity.

② Impulsivity and metacognition

The results (Fig. 2) supported our hypothesis that impulsive species, such as pigeons, do not show metacognitive behaviours even when the cost of that response is minimised. Furthermore, the results suggested that their responses were based on the perceptual characteristics of the stimuli used in the task. This possibility was further supported in a modified version of the original task with increased response cost for non-metacognitive choice.

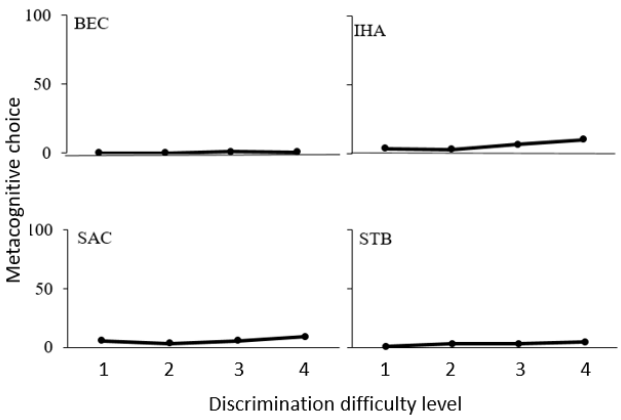

Fig. 2. Metacognitve behaviour across task difficulty in four subjects

(3) Spatial attention to movement in pigeons

① Sensitivity to non-social cues

Using the novel procedure to measure pigeons' sensitivity to moving stimuli, data on pigeons' threshold was successfully collected and calculated. This data is useful for designing any cognitive task involving moving stimuli as well as providing insights into the

mechanisms of temporal resolution in vision. The results from this study was presented at a national conference in 2021.

② Sensitivity to social cues

The results showed that although pigeons do not have innate tendency to follow conspecific's gaze, they can learn to use it as a cue. The results from this study were presented at an international conference in 2022 and at national conferences in 2020 and 2022.

(4) Designing memory-based tests for pigeons

① Visual short term memory task

Unlike humans, pigeons had a great difficulty in learning the same/different discrimination of multiple items. On the other hand, they showed a similar pattern to humans in identifying the changes in the items when their attention was disrupted briefly. The results from this study were presented at an international conference in 2022 and at national conferences in 2021 and 2022.

② Source memory

Consistent with previous research, the pigeons had difficulty in solving the original task but were successful in learning the task using limited stimulus set size.

In sum, above results suggest future directions for impulsivity research, especially in the methods of obtaining appropriate impulsivity measures and in investigating the relation between impulsivity and other psychological attributes, including memory.

５．主な発表論文等

〔雑誌論文〕　計0件

〔学会発表〕　計8件（うち招待講演　0件／うち国際学会　2件）

１．発表者名 Nakauchi, D.,Ushitani, T., & Watanabe, A.
２．発表標題 Gaze cueing effect in pigeons (Columba livia)
３．学会等名 29th Annual International Conference on Comparative Cognition（国際学会）
４．発表年 2022年

１．発表者名 Shimada, K., Watanabe, A. & Ushitani, T.
２．発表標題 The difficulty of learning same-different discrimination in pigeons (Columba livia)
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４．発表年 2022年

１．発表者名 Nakauchi, D.,Ushitani, T., & Watanabe, A.
２．発表標題 Does conspecific’s head movement capture pigeon’s (Columba livia) attention?
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Do cats prefer to watch and respond to random movements?

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１．発表者名
Nakauchi, D., Watanabe, A., & Ushitani, T.

２．発表標題
Do pigeons (Columba livia) show "gaze" sensitivity?

３．学会等名
The 80th Annual Meeting of the Japanese Society for Animal Psychology

４．発表年
2020年

〔図書〕　計0件

〔産業財産権〕

〔その他〕

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６．研究組織

	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

〔国際研究集会〕　計0件

８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関