Annual Report, 2022, vol.1, 1-17

Elucidation of factors shaping sociality in adolescents and creation of a developmental model: A cohort study outline

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This article is an overview of the Study that the JAPAN CHILDREN STUDY GROUP has done since 2004 supported by the Japan Science and Technology Agency and Japan Society for the Promotion of Science (Research Project No. 21243039, 15H03453, and 19H01759). The relationship of the main outcome (Social behavior of adolescent age) and exposures (multi environmental factors from birth to adolescence) has been examined. We are now applying the Dynamic systems model on the over 1000 items data from birth to adolescent age. We also analyzing the DNA methylation of the participants. On this article, we try to review the research so far and serves as an interim summary.

Keywords: cohort study infant to adolescence, dynamic systems approach

Research background

No human being can live alone either biologically or psychologically. The dependence of newborns and infants on caregivers is the obvious indication of this. Immediately after birth, various communication methods are activated to enable the baby to develop relationships with others to ensure its survival; these include physical activities such as crying and throwing your head back. These channels also work to create psychological connections with the social environment through interactions such as mother-child eye contact and playing. It would be natural to think that the quality of these social relationships with the surroundings are related to later development. This is the most fundamental question of development and has long been debated from the point of view of whether it is the environment (learning) or heredity (innateness) that shapes people. This question is addressed in the first volume of the *Handbook of Developmental Psychology and Developmental Science*, published last year (Ninomiya & Koyasu, 2022), so the debate is ongoing. In recent years, moving away from the dichotomy between heredity and environment, two new concepts have emerged— epigenetics, which says that gene expression is affected by environmental factors (Hajime et al., 2013), and the dynamic systems approach, which attempts to explain developmental phenomena through the interactions between countless elements involved in human development (Fogel & Thelen, 1987; Thelen & Smith, 1998).

In order to clarify the interactions between heredity and environment, it is necessary to track changes in individuals over time. When trying to identify chronological changes in behavior, it

is effective to use a cross-sectional research method of extracting behavioral characteristics by age group. However, the problem is that while this method can detect group differences by age, it cannot take into account individual differences in development. There is a confounding of individual developmental tendencies, whether the same behavior appears earlier or later than the measured age. Measuring developmental changes in behavior by considering such individual differences requires a longitudinal research method tracking the development of individual children. However, longitudinal studies require time, money, and, above all, long-term cooperation of the participants. Even when it comes to connecting the individual data, it is necessary to conduct a panel survey that repeats the same measurement content and a survey according to the developmental stage. Hence, short-term longitudinal studies focusing on developmental changes in specific behavioral traits are the main focus in Japan.

Under such circumstances, this study is essentially the only longitudinal study in Japan in the field of psychology to produce cleaned multifactorial data from participants aged 0 to 18 years. The study aim is to elucidate which factors in an individual's developmental process are associated with adolescent social behavior, an issue that continues to be a matter of concern. In order to answer the big question of whether the determinant of adolescent social behavior is parental childrearing attitudes or individual temperament and brain functions, mother-child interaction observations and physician observations were planned from 4 months of age.

This study is part of the “Brain Science and Society” research and development effort and the planned research and development project entitled “Elucidation of factors affecting children’s cognitive and behavioral development in Japan” helmed by the Research Institute of Science and Technology for Society (RISTEX) of the Japan Science and Technology Agency (JST). The project was launched with the help of participants sampled at hospitals in Nishinomiya City, Hyogo Prefecture and Hisai City and Owase City, Mie Prefecture. Even after the completion of “Elucidation of factors affecting children’s cognitive and behavioral development in Japan” (2004-2008), follow-up research was continued in Mie and Hyogo from 2009 to 2013. Scientific Research (A) (Research Project No. 21243039) from 2009 to 2013, Scientific Research (B) (Research Project No. 15H03453) from 2015 to 2018, and Scientific Research (B) (Research Project No. 19H01759) from 2019 to 2021 were continued at the Center for the Study of Child Development, Mukogawa Women’s University, in order to achieve the original objective. Research results have been presented at academic conferences and journals in Japan and overseas. Data have been made available as open access data that can be used by young researchers under certain review through submissions at independent workshops of the Japanese Society of Developmental Psychology and as research papers in developmental psychology over several years. In FY2023, this study is to be reviewed by the Center for the Study of Child Development with Tatsuo Ujiie, former president of the Japan Society of Developmental

Psychology, as the team leader.

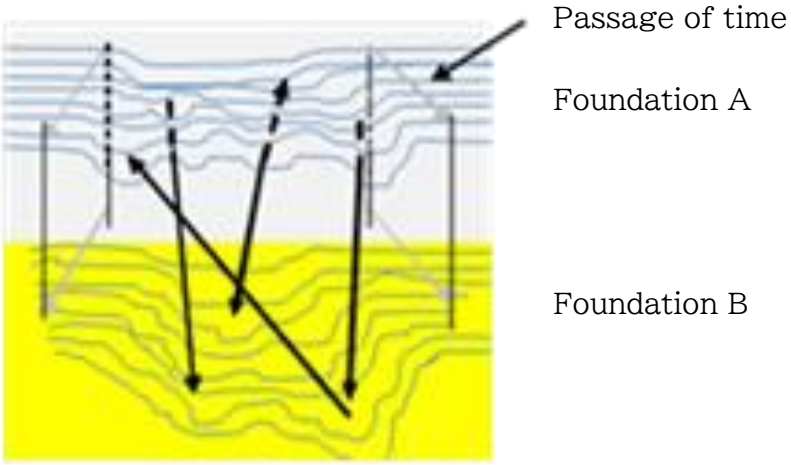
Problem formulation

There are two main problems that this longitudinal study attempts to clarify: 1) How does the relationship between environmental and genetic factors with regard to developmental changes affect social behavior? 2) Is children's social behavior with adults and peers determined by caregivers' views and values of childrearing or by biological and temperamental characteristics such as sensitivity to reactions. Furthermore, it is possible to challenge the recent developmental theories that have appeared in opposition to such dualistic developmental models. The dynamic systems approach, proposed by Fogel and Thelen (1987), holds that human developmental changes are not pre-programmed but emerge through the interactions of the sub-elements that make them up. It is assumed that dynamic relationships between elements create new behaviors.

Figure 1 shows Thelen and Smith's (2002) theory of multilayered interactions between functions based on the developmental model of Waddington (1957). The goal of development is indicated at the base, and the valley leading to it is shaped depending on which elements contribute at the top, so that transitioning to a valley toward a different goal is initially possible with very slight changes in elements. However, as development progresses, the valley becomes deeper, which makes it impossible to cross peaks and transition to parallel valleys to pursue other

courses of development. In this study, we examine the relationship between individual environmental factors at each developmental stage as exposure, using social behaviors such as self-identity in adolescence and conflicts in parent-child relationships and career decisions as outcomes.

Figure 1
Multilayer model

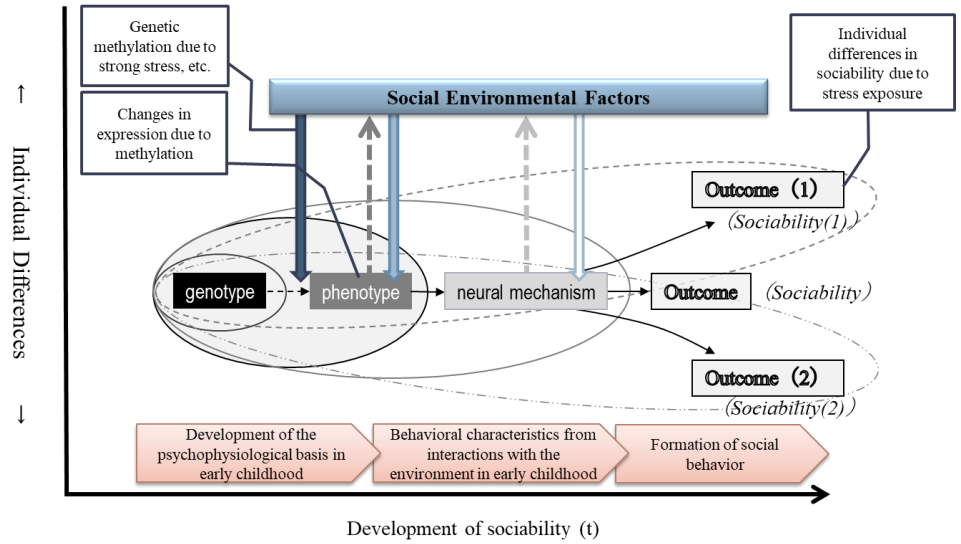


Another developmental issue that this study looks at is epigenetics. It attempts to explain the mechanisms of development based on the interactions between heredity and environment (Sameroff, 1975; Ford and Lerner, 1992). An important point in this line of thinking is that development is shaped by the interactions of genetic and environmental factors, and interactions with the environment determine whether or not certain genetic characteristics are manifested in an individual (Figure 2).

In our study, which defines social behavior as an outcome, individual characteristics at birth interact with parents' childrearing attitudes, SES, and childcare environment to produce

behaviors with individual characteristics. At the same time, the interactions lead to ethylation of certain genes, resulting in degeneration of the genes themselves, which affects subsequent behavior. In this study, a medical research group has started genetic analysis to investigate the ethylation of genes that occurs when a participant is under severe stress. Some of these results are also reported here.

Figure 2
Conceptual diagram of individual differences in sociability presuming an epigenetic process



(Note) Outcome behavior are formed through interactions between biological factors, centering on expression of genes and specific genes, and social environment factors in the individual's daily life. The environment affects behavior and behavior affects biological systems. These changes in biological systems finetune behavior, which in turn changes the interactions with the environment. This chain of events can lead to variability in individual outcomes.

There are several models of developmental change, but these are likely intricately intertwined to create development. For example, looking at the mother-child relationship in the early

stages of development, which was our focus in this cohort, many factors such as language, emotion, motivation, sensorimotor function, and the nurturing environment including maternal characteristics are related to each other with various time lags. Adding to the complexity is the relationship between observed behavior and its functions. This can also be summarized by the ideas of homology and similarity. For example, pointing and vocalization as interpersonal actions function in the same way, but the observed behaviors are quite different. The number and quality of conversations with the mother in the mother-child relationship assume different meanings depending on the stage of development. Such discussions require an examination of outcomes and exposures from a developmental perspective, while also considering homology and similarity.

In this study, we not only track more than 7,000 items from birth, plot them, and clarify the course of development, but also analyze their relationships cross-sectionally for multiple factors at multiple points in time, proposing the mechanisms that seem to exist there. Analysis from this perspective is done by Takeshima et al. (to be published). With environmental factors as exposure, data such as feelings toward the child during the fetal period, interpersonal feelings after birth, the mother's behavior in mother-child interactions at 4 months of age, parents' views on childrearing, the father's involvement in childcare, SES, changes in the family environment such as changing jobs, peer relationships at school, and class adaptation were collected to enable further analysis. Individual factors of the child including physiological

state after birth, cognitive ability, motor function, language function, sensorimotor coordination, and resilience were measured using developmental tests. Even before adolescence, sociality as an outcome is measured by developmental tests for social behavior toward children and adults, self-restraint behavior in interactive situations, class adaptation, and so forth, and from an ecological perspective, with the consent of parents and nursery teachers, teachers evaluate group behavior in nursery schools and kindergartens. Behavior during interactions in the observation room is analyzed.

Purpose and originality of this research

The purpose of this study is to elucidate the relationship between individual and environmental factors in infancy and childhood, with social behavior in adolescence as an outcome and environmental factors in adolescence as exposure, as well as to create a developmental model of how social behavior in adolescence is shaped by the relationship between the characteristics of social behavior in adolescence and various factors from the early stages of development. The results of early childhood and later childhood studies, which have already been analyzed, have revealed a discontinuity in social development from early childhood to later childhood. Although not analyzed in this report, as of 2023, participants' relationships with family and friends have changed significantly as they reach high school age, so it will be possible to examine the relationship between self-

outlook factors such as social relationships, peer relationships, and career decisions in the home and exposure factors in infancy and

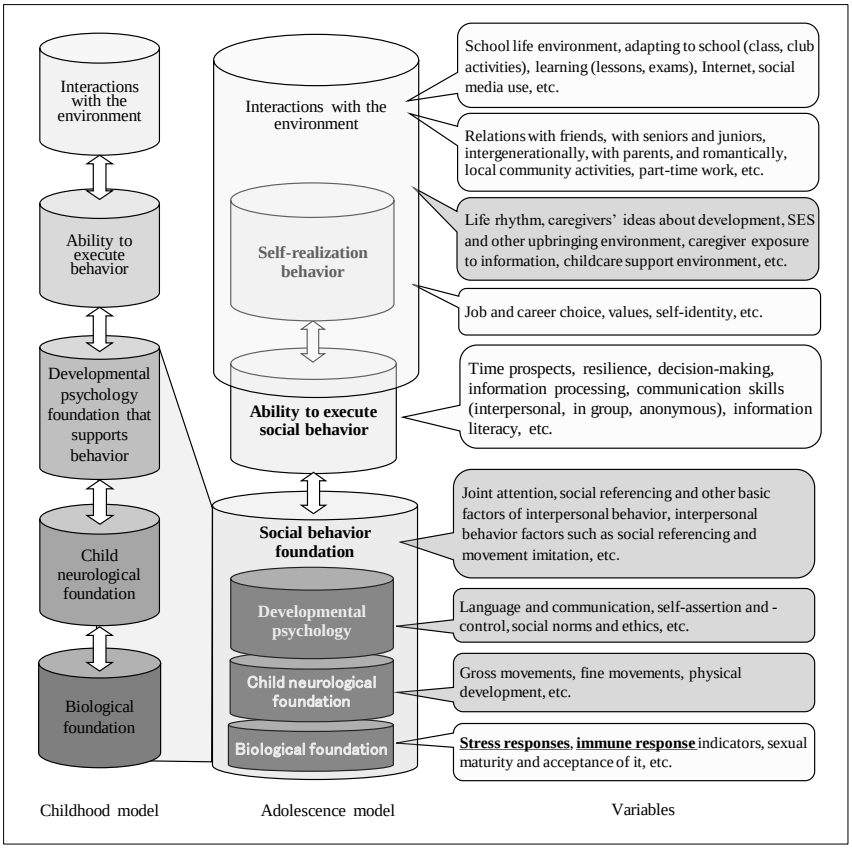


Figure 3

Determinants of development and various variables (grayed areas are accumulated variables)

Note. Interactions with the environment happen in adolescence based on the foundation accumulated in childhood. Compared to childhood, social behavior becomes a stronger determinant.

childhood through detailed surveys that cover the observation of parent-child interactions as well as how individual factors are interrelated chronologically. At the same time, we will examine the abusive tendencies and aggression of caregivers related to intergenerational transmission from the perspective of the

relationship between childrearing attitudes listed as survey items in early childhood and views on childrearing in the adolescent period.

One characteristic of this study is that continuous cooperation between 185 parents and participants can be maintained, and a total of 7,090 question items (the average of 16 surveys at the time of this survey is about 443 items), items observed by physicians up to the second grade of elementary school, other observation items such as evaluation of behavior in the observation room, and basic items such as WISC and saliva are accumulated (Figure 3).

Research organization

The follow-up research has been conducted in teams since its inception. While the teams continue research with their own research themes, the department provides advice on the examination of results from the perspectives of statistical analysis and modeling, medical and genetic measurement and analysis, and theoretical examinations. The quality control department for data collection and cleaning allocates personnel who are not researchers but can handle data continuously, and it has been conducting quality control from the beginning of the study. These survey data and observation data from the age of 0 are managed in the data vault of the Center for the Study of Child Development, Mukogawa Women's University, where imports and exports are automatically recorded, and whose storage is mechanically backed up.

With regard to open access, we are implementing procedures such as formulating regulations and facilitating explanations to and consent from participants regarding secondary use of cleaned data up to the middle school level on a trial basis for developmental researchers at Mukogawa Women's University.

Domestic and international trends and the significance of this study

The spread of the COVID-19 pandemic was first reported in Japan in December 2019. In January 2020, a human infection also occurred in Japan, and after that, a series of social changes occurred, including the government's requests to restrict movement. Under these circumstances, group play and face-to-face classes were restricted, and the environment surrounding children changed rapidly, all the way up to the year 2023, when this report is being written. During this period, many changes that seem to affect children's social behavior have occurred rapidly, such as the introduction of remote classes by distributing tablets to students and the activation of social-media-based communication among children.

Kisu and Yasukawa (2021) argue that children experienced "loss of environment" and "loss of self-image" during the pandemic, in the sense that school closures and the virtualization of club activities and lessons has suddenly created barriers between the children and the goals they had been striving for. They lost their

goals, their roles in class, their sense of belonging with their friends, and their self-image, leading to a sense of loneliness.

Although it is not possible to predict at this stage how these changes will affect children's social behavior, it may be presumed that changes in the environment surrounding children are related to developmental changes. Our follow-up research has attempted to clarify how such social changes, the living environment of caregivers, and their attitudes are related to children's social behavior. The pandemic, a major threat to humanity, arose during the follow-up, and perhaps no other study has captured changes in children before and after the pandemic. If systematic cohort studies had been conducted before, perhaps it would have been possible to devise preventative models to mitigate the impact and negative effects of the pandemic on development.

However, longitudinal research is rarely done in Japan because it places a heavy burden on participants and researchers. There is a similar tendency abroad. The population-based National Children's Study (NCS), launched by the NIH in the wake of the 2000 Children's Health Act, planned to follow 100,000 children from birth to age 21, but there were issues with research funding, retention of participants, and research methodology, so it ended in 2014 despite opposition from the researchers. A large cohort study has also been launched in the UK. "Born in Bradford," a hospital-based project that started in 2007, continues to track 12,000 people. In Japan, the Ministry of the Environment has been conducting a large-scale epidemiological survey of 100,000 mothers and children, the "National Survey on Children's Health

and the Environment" (Eco-Child Survey), since 2011. In this study, the central hypothesis is about "whether environmental factors such as chemical exposure from the fetal period through childhood affect pregnancy and reproduction, congenital malformations, neuropsychiatric development, immunity and allergies, metabolism and endocrine systems, and so forth."

The importance of longitudinal research is described by Takahashi (2009), but Japan has not produced much knowledge regarding developmental psychology that can be conveyed to the rest of the world.

Ethical considerations

The participants of this research are all the people who have cooperated with the study so far. The purpose and social significance of the study is fully explained to the participants at each developmental stage; thus, their participation is based on their full consent. In addition to this, as mentioned above, when we send out information about the study every fiscal year, we try to convey how the survey contents are being used, for example by publishing results that can be disclosed in a newsletter. Regarding the acquisition of a consent form, in the case of face-to-face surveys and interaction observations, the consent form is filled out after face-to-face explanation and acceptance of questions. Moreover, in consideration of cases where it is difficult to directly refuse or withdraw consent, a consent withdrawal form via the

ethics committee is also distributed at the same time. In the case of survey by mail, a research description is sent to explain and obtain consent. When conducting questionnaire surveys, it is clearly stated that you do not have to answer items that you do not want to answer, that there will be no disadvantages due to this, and the information will not be used in a way that makes it possible to identify individuals.

Since the content of this survey is strongly related to the self-image of adolescents, it is important to: inform parents regarding what explanations should be provided to the children, provide sufficient explanations to the children themselves, and prepare return envelopes for the children. Since entering middle school, the cohort study has been explained to the children themselves to obtain direct consent from them.

Moreover, gene methylation analysis by saliva sampling, a non-invasive method, has been approved by the ethics review committee for genome and DNA analysis at Mukogawa Women's University and Mie Central Medical Center in accordance with the ethical guidelines for human genome and gene analysis research to allow us to handle genetic information. For observations of research participants under the age of 16, we follow procedures based on the "Guidelines for the Implementation of Research on Students, Children, and Young Children in Schools, Kindergartens, and Nursery Schools" of the Mukogawa Women's University Institute for Education Code of Ethics 04-06-2.

Regarding the detection of accidental diseases discovered in the course of research, information and advice are provided at the

discretion of the researchers to prioritize the interests of the participants, but there have been no such cases so far. In cases where advice is sought, doctors and clinical psychologists consult with each other before answering.

Regarding the management of information, we thoroughly manage personal information by double anonymization and protect storage media with passwords, strictly storing it in a data management room equipped with a fingerprint matching system at the Center for the Study of Child Development, Mukogawa Women's University.

The members of the research group, including assistants, receive ethics education through e-APRIN.

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Conflict of interests

The authors declare no conflicts of interest associated with this manuscript.

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