The Adaptive Function of Solitude from a Lifespan Development Perspective: A Five-Wave Comparison of Benefits and Costs

Authors: Arsheng Haidarbek, Zhou Tong, Yu Jie, Wang Jiyueyi, Chen Fei, DING Xuechen, Ding Xuechen

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Abstract

Solitude is a state in which an individual has no communication with others in both real and virtual environments. From childhood to late adulthood, solitude exerts different influences across various developmental stages of an individual. Regarding the adaptive functions of solitude, previous researchers have held divergent perspectives, either positive or negative, with one viewpoint positing that solitude possesses both benefits and costs. Given the inconsistency among researchers' viewpoints on solitude, the present study adopts a lifespan development perspective to systematically review relevant research on the benefits and costs across different developmental periods, examine their dynamic changes and development, and proposes a comparative model of the benefits and costs of solitude from a lifespan development perspective. Future research could place greater emphasis on person-centered approaches, integrate the multidimensional nature of solitude, collect cross-sectional and longitudinal data for direct comparison from a lifespan development perspective, enrich the developmental mechanisms underlying the benefits and costs of solitude, understand the connotation of solitude in conjunction with cultural contexts, attend to the impact of contemporary digital technology development on individual solitude, investigate the cognitive neural mechanisms of solitude, and contemplate the practical implications of solitude across different age groups.

Full Text

Understanding the Adjustment Functions of Solitude from a Lifespan Development Perspective: A Five-Round Comparison of Benefits and Costs

HAIDABIEKE Aersheng[1], ZHOU Tong[2], YU Jie[1], WANG Jiyueyi[1], CHEN Fei[3], DING Xuechen[1,4]

[1]School of Psychology, Shanghai Normal University, Shanghai 200234, China
[2]School of Psychology and Cognitive Science, East China Normal University, Shanghai 200062, China
[3]Zhangjiang Hi-Tech Experimental Primary School, Pudong New District, Shanghai 201203, China
[4]Lab for Educational Big Data and Policymaking, Ministry of Education, Shanghai 200234, China

Abstract: Solitude is a state in which individuals have no communication with others in real or virtual environments. From childhood to old age, solitude exerts different influences across developmental stages. Regarding the adjustment functions of solitude, researchers have held divergent views, ranging from positive to negative perspectives, with some arguing that solitude entails both benefits and costs. Given these inconsistencies, this study adopts a lifespan development perspective to review research on the benefits and costs of solitude across various developmental periods, examining their dynamic changes and developmental trajectories. We propose a comparative model of solitude's benefits and costs from a lifespan perspective. Future research should focus more on person-centered approaches, integrate the multidimensional nature of solitude, collect cross-sectional and longitudinal data from a lifespan perspective for direct comparisons, enrich developmental mechanisms underlying solitude's benefits and costs, understand solitude's meaning within cultural contexts, examine the impact of contemporary digital technology development on individual solitude experiences, investigate the cognitive-neural mechanisms of solitude, and consider the practical implications of solitude across different age groups.

Keywords: solitude, lifespan development perspective, adjustment function, benefits, costs

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Introduction

In the past, researchers have focused primarily on the significance of social interaction and interpersonal relationships for individual development, relatively neglecting the impact of solitude [**?**]. In reality, however, solitude coexists with social interaction throughout human life, and both represent equally important developmental needs that can resolve conflicts and reduce pathology [**?**]. Every organism must seek a balance between intimacy and solitude [**?**]. Throughout

development, individuals experience solitude for various reasons and engage in different behaviors during solitary periods, producing diverse outcomes. Some may use solitude as a respite when facing life stress, for quiet contemplation, creative cultivation, or communion with nature, while others may suffer from solitude due to social isolation [**?**]. This complexity suggests that solitude is a multifaceted phenomenon.

Researchers have offered different definitions to address this complexity. Earlier, Burger [**?**] defined solitude as a state without any social interaction, while Larson [**?**] viewed it as a state of conscious separation from others without information or emotional exchange, emphasizing psychological rather than physical distance. Subsequently, Long et al. [**?**] proposed that solitude is an objective state of non-interaction with others in either real or virtual environments. However, as digital technology has become ubiquitous, our conceptualization of solitude may be completely reshaped [**?**]. Campbell and Ross [**?**] recently argued that in the digital age, solitude should be redefined from "being alone" to "non-communication." These definitions converge on conceptualizing solitude broadly as a behavioral state lacking interaction or communication with others, distinct from loneliness, which involves only negative emotions. In this study, we conceptualize solitude as a state of non-communication with others in real or virtual environments that can accommodate diverse emotional experiences.

Adaptation is an indispensable element of individual development, reflecting both current developmental status and future developmental value. In recent years, researchers have continuously explored the adjustment functions of solitude [**?**, **?**, **?**, **?**], holding divergent views: some studies suggest solitude may be accompanied by negative emotions such as loneliness [**?**, **?**], others view solitude as a positive experience [**?**], and some propose that solitude is a double-edged sword with both benefits and costs [**?**]. Given these controversies, this study selects key variables such as psychological and social adjustment, proposing to examine the comparison between benefits and costs of solitude across different life stages from a lifespan development perspective to better understand solitude's dynamic changes and development. This approach extends Coplan, Ooi et al.'s [**?**] temporal effects model of solitude development, revealing that solitude has different adjustment functions at various ages due to differing developmental tasks, thereby providing a more comprehensive explanation of solitude's significance for individual adaptation.

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2. Round One: Costs of Solitude Dominate in Childhood

For young children, solitude is often described as solitary play, a very common phenomenon [**?**]. Researchers consider solitary play (e.g., onlooking, banging blocks, pretend play, trying to understand toy mechanisms; [**?**]) an important condition for the development of social interaction in preschoolers [**?**]. For example, reticent behavior serves as a bridge for most children to develop norms

between solitary and social play, progressing from watching others play (onlooking), to playing alongside other children (parallel play), to social engagement (group games and peer conversation) [?].

However, solitude in childhood may bring more negative than positive effects. Children who prefer solitude not only tend to develop maladaptive thought patterns [?], but their social competence development is also inhibited. Research has found that children who choose solitude face more peer interaction difficulties [?, ?, ?, ?], greater behavioral inhibition [?], more internalizing problem behaviors [?, ?], and poorer school adjustment [?]. Recently, a cross-sectional age-comparison study found that compared to adolescence, childhood preference for solitude has a stronger association with socio-emotional adjustment difficulties [?]. This may be because from early childhood, both the quantity and quality of children's peer interactions gradually increase, with peer interaction becoming the norm in children's daily social environments [?]. Children's social, emotional, and cognitive development and mental health all require substantial positive peer interactions as a guarantee [?]. For instance, researchers found that when asked to choose playmates between socially competent peers and peers who frequently play alone, even when the solitary playmate was described as likable, young children still reported not wanting to play with them [?, ?].

In summary, during childhood, although solitary play provides a foundation for developing social skills, it also causes children to miss opportunities for peer interaction during a critical period for social development, thereby negatively impacting socio-emotional adjustment. Therefore, at this developmental stage, the costs of solitude dominate.

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3. Round Two: Costs of Solitude Peak in Adolescence

Adolescence is considered an important and unique developmental period for solitude [?]. The "Goldilocks Hypothesis" suggests that adolescents have a "just right" frequency of solitude, with both too much and too little being problematic [?]. Excessive solitude time is detrimental to establishing and maintaining peer relationships [?], while insufficient solitude brings negative emotions and feelings [?]. During this period, solitude receives particularly extensive attention and discussion, and its adjustment functions begin to transition and transform. Fromm-Reichmann [?] proposed "growing aloneness" from a developmental perspective to depict solitude phenomena beginning in adolescence. For example, a U.S. study tracking 383 children from kindergarten through 12th grade over 13 years found that preference for solitude increased with age, with the growth rate accelerating during adolescence compared to lower grades [?]. In a Chinese context, Hu et al. [?] found similar growth trajectories among adolescents aged 13-16. This developmental characteristic may be related to psychological adjustment in later adolescence [?, ?], as children who prefer solitude begin to desire and enjoy solitary activity time [?, ?], with increasing desire for privacy [?] and

more positive attitudes toward solitude [?, ?]. This constructive solitude may positively impact adolescent development [?, ?, ?].

Nevertheless, the costs of solitude during this stage likely still far outweigh its benefits. Given the crucial importance of peer relationships for adolescent development, solitude may limit opportunities for adolescents to form positive peer relationships and learn key social skills [?]. Whether in early, middle, or late adolescence, solitude is more clearly associated with negative adjustment outcomes. For example, numerous studies have found that preference for solitude is related to internalizing problems such as depression and low self-esteem in early adolescence [?, ?, ?], and to peer rejection [?, ?]. Coplan and Ooi et al. [?] argue that early and middle adolescence are the ages when solitude is most likely associated with negative adjustment. Meanwhile, solitude in late adolescence has been shown to correlate with negative emotions such as anxiety, loneliness, and depression [?], and with low peer interaction competence [?].

Adolescent solitude has unique characteristics. As adolescent autonomy develops, preference for solitude also increases. "Just right solitude" and "growing aloneness" may help adolescents engage in self-exploration. However, despite this, adolescent solitude still tends to produce various internalizing behavior problems and risks of social maladjustment, with the costs of solitude continuing to rise and reaching their peak during this stage.

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4. Round Three: Benefits of Solitude Gradually Emerge in Emerging Adulthood

From an object relations theory perspective, Winnicott [?] used the term "paradox" to explain that the capacity for solitude in adults originates from secure attachment in infancy, making emerging adults increasingly accepting of solitude [?]. As autonomy continues to develop and identity roles shift, emerging adults show stronger motivation to seek solitude and expect to obtain rest through "spending quiet time alone" [?]. Recent research has proposed two independent motivational structures for solitude in emerging adulthood: self-determined and non-self-determined solitude, finding that self-determined solitude motivation is associated with higher well-being in self-acceptance and personal growth [?], significantly increases opportunities for positive solitude experiences [?, ?], alleviates loneliness in individuals with low sense of belonging [?], and relates to positive adjustment outcomes [?]. Meanwhile, for young people who actively choose solitude, it can bring relaxation and stress reduction without being troubled by intrusive negative thoughts during solitude [?, ?].

Although the capacity for solitude is considered a benign developmental characteristic in emerging adulthood [?, ?], some studies have found positive correlations between preference for solitude and negative emotions in emerging adults [?]. The reason may lie in the match between solitude attitudes and motivations. For example, Zhou et al. [?] used latent profile analysis to explore differ-

ent solitude subtypes among Chinese university students, finding that among four solitude subtypes, the positive solitude-motivation-driven group showed the highest level of autonomous solitude motivation and highest preference for solitude, with good adjustment. In contrast, the negative solitude group showed the highest level of aversion to solitude and lowest autonomous motivation. These results suggest that when solitude attitudes (preference vs. aversion) align with motivations (self-determined vs. non-self-determined), preference for solitude in emerging adulthood may bring positive developmental outcomes [?].

In emerging adulthood, the negative effects of solitude shift, with costs no longer holding absolute dominance. Self-determined solitude motivation contributes to self-acceptance, and the benefits of solitude gradually emerge. Therefore, at this stage, solitude motivation and attitude remain key factors determining adaptive outcomes, with inconsistency between them potentially creating maladjustment risks.

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5. Round Four: Benefits and Costs of Solitude Are Balanced in Middle Adulthood

Although researchers consider solitude a common experience throughout adulthood, sometimes exceeding time spent with others [?, ?, ?], middle adulthood involves the heaviest parenting responsibilities and life pressures due to specific life-stage goals and social roles [?], leaving less time or freedom for solitude [?, ?]. Correspondingly, middle-aged individuals may have high desires for solitude due to escapism [?], showing more autonomous solitude motivation and greater preference for solitude than emerging adults [?, ?]. Their self-determined motivation may flourish with improved solitude capacity and better self-regulation [?], with supporting evidence. For example, two experience-sampling studies from emerging adulthood to older adulthood found that older individuals with higher autonomy experienced daily solitude moments more positively [?]. Middle-aged adults seek solitude by spending time on themselves, engaging in regulatory activities (e.g., meditation) that direct attention inward to restore energy [?], or engaging in more self-reflection during solitude, cultivating patience and spiritual investment [?], which may bring long-term developmental benefits [?].

On the other hand, solitude in middle adulthood also entails potential risks. A recent cross-sectional study during the pandemic found that compared to adolescents and older adults, although middle-aged individuals had the strongest autonomous motivation, they experienced more emotional fluctuations during solitude and felt that solitude time undermined their well-being and sense of familiarity with their surroundings [?]. Notably, during the pandemic, participants may have experienced atypical solitude states that disrupted the balance between social and solitary time [?]. As middle-aged adults experience changes in life goals, challenges, environments, and demands [?], solitude preference changes from emerging to middle adulthood and relates to different emotional

states. Research has found that higher levels of solitude preference correlate negatively with socio-emotional well-being, such as increased loneliness, decreased life satisfaction, and reduced positive affect [?, ?, ?]. This aligns with previous researchers' view of "solitude as a double-edged sword" [?]. Whether it represents benefit, cost, or both depends on one's motivation and preference for solitude [?]. Accordingly, one study found that for mothers who enjoy solitude, positive solitude helps buffer the impact of parenting stress on psychological adjustment, while for mothers with low solitude preference, involuntary solitude exacerbates negative psychology after stress and reduces marital satisfaction [?].

After middle adulthood, individuals experience identity shifts and face heavy parenting responsibilities and life pressures, creating higher needs and autonomous motivation for solitude to achieve relaxation or self-regulation. However, solitude at this stage still negatively impacts socio-emotional adjustment, with benefits and costs being roughly balanced and difficult to differentiate.

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6. Round Five: Costs of Solitude Rise Again in Older Adulthood

Although solitude runs throughout life, solitude time is relatively longest in older adulthood, with some older adults spending 71% of their time alone [?, ?]. Diekema's [?] Aloneness and Social Form perspective suggests that each solitude state implies unique meaning for individual-group relationships, with solitude predicting fewer negative effects for individuals with more social network conflict [?]. This suggests solitude may benefit older adults, as those showing more preference for solitude also report more positive solitude experiences, less loneliness, less negative affect [?, ?, ?], and more enjoyment of solitude [?]. A recent study [?] comparing solitude preferences across young, middle-aged, and older adult groups provided more direct evidence: older adults reported both more solitude time and more positive emotions than other groups.

Contradicting this evidence, another diary study of individuals aged 18-84 over 10 days found that longer average solitude time correlated with stronger loneliness, with this association being more pronounced in older individuals [?]. Thus, even for older adults, solitude still contains both positive and negative meanings [?], and one cannot simply assume that solitude preference in older adulthood has absolute positive significance. The death of social network members or retirement-related social role changes cause older adults to objectively experience more forced solitude [?, ?], and the costs of this forced solitude are also dangerous. For example, older adults living alone face social isolation risks due to declining health, disability, and death of partners and friends [?, ?]. If older adults' autonomy needs are unmet due to physical reasons and solitude becomes a forced choice, this social isolation also causes maladjustment [?, ?], such as increased depression risk and lower life satisfaction [?, ?, ?], creating many negative effects.

Overall, compared to other adult stages, individuals in older adulthood have more discretionary time and higher autonomy regarding solitude, allowing them to regulate emotions and enjoy solitude through it. At the same time, however, older adults are more vulnerable to social isolation and forced solitude, which threatens cognitive, emotional, and social well-being, causing the costs of solitude to rise again.

In summary, this study discusses the developmental characteristics and adjustment functions of solitude from childhood to older adulthood from a lifespan perspective, revealing that solitude is indeed a double-edged sword with both benefits and costs for individual development. Overall, solitude shows different characteristics across age stages: solitary play in childhood → self-exploration and entertainment in adolescence → work and rest in emerging adulthood → relaxation and reflection in middle adulthood → problem-solving and emotion regulation in older adulthood. Moreover, the manifestation of benefits and costs differs across stages. In childhood, solitary play serves as a bridge for developing social functions but directly causes missed peer interaction opportunities, with costs dominating. In adolescence, despite greater social autonomy, increased social expectations and norms make solitude prone to various internalizing problems and peer pressure, with costs peaking. In emerging adulthood, self-determined solitude motivation contributes to self-acceptance and personal growth, with benefits gradually emerging, though inconsistent motivation and attitude may still generate negative emotions. In middle adulthood, identity shifts create higher needs and autonomous motivation for solitude, but different socio-emotional gains and losses emerge, making benefits and costs roughly balanced. In older adulthood, individuals have high autonomy and begin enjoying solitude, but face social isolation that threatens cognition, emotion, and life, causing costs to rise again.

Finally, this study presents a comparative model of solitude's benefits and costs from childhood to older adulthood from a lifespan perspective (see Figure 1).

[Figure 1: see original paper] Comparative Model of Solitude's Benefits and Costs from a Lifespan Development Perspective

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8. Thoughts and Prospects

Exploring solitude from a lifespan development perspective has important theoretical and practical significance, as solitude and interpersonal interaction coexist at every stage of life development and exert positive or negative influences on individual development. Although previous researchers have noted the adjustment functions of solitude in children and adolescents, theoretical explanations and developmental trajectories still have several limitations that require future exploration and improvement.

8.1 Person-Centered Perspective: Integrating the Multidimensionality of Solitude Although many researchers have examined solitude from different angles, most current research uses variable-centered approaches, with few studies simultaneously investigating the multidimensional characteristics of solitude states. Previous perspectives suggest that solitude is a complex and multidimensional state [**?**], making such integration necessary for understanding this complex phenomenon. Examining only one dimension often leads to biased understanding, such as assuming that preference for solitude indicates maladjustment while ignoring motivations for choosing solitude. Integrating multiple dimensions of solitude can better capture potential individual differences in behavior and deeply explore the concept itself from different angles [**?**]. Currently, only a few studies use person-centered approaches to integrate multiple dimensions of solitude [**?**, **?**, **?**, **?**, **?**]. Due to the flexibility of variable selection in person-centered approaches, these studies' results cannot be directly compared. Future research should systematically integrate the multidimensional structure of solitude using person-centered methods (e.g., latent profile analysis) across different developmental stages.

8.2 Lifespan Development Perspective: Directly Testing the Dynamic Development of Solitude's Adjustment Functions Exploring solitude from a lifespan perspective requires attention to its unique functions at different developmental stages. Although Coplan and Ooi et al. [**?**] proposed a temporal effects model of solitude development, and many researchers have noted the adjustment functions of solitude at different ages [**?**, **?**, **?**, **?**], most solitude research remains limited to child and adolescent development, with insufficient research on adulthood and older adulthood. Moreover, most evidence is scattered and difficult to integrate for direct comparison. Only a few studies have attempted to directly compare differences in social adjustment functions between childhood and adolescence [**?**, **?**], with broader age-range direct comparisons still lacking. Therefore, future research should not only further compare the benefits and costs of solitude from childhood to older adulthood through large-sample cross-sectional studies but, more importantly, use longitudinal studies to comprehensively examine how the benefits and costs of solitude dynamically change across developmental stages within the same cohort. Finally, meta-analysis can help us more intuitively and precisely understand the relationships between solitude and various indicators of individual adjustment functions.

8.3 Understanding Solitude's Developmental Process Within Cultural Contexts Cultural factors must be considered when understanding solitude, as attitudes toward and understanding of solitude differ across cultures, and examining cultural differences helps better comprehend this phenomenon [**?**, **?**, **?**]. For example, Western cultures emphasize individual free will, making solitude more likely to be understood as personal choice and thus more accepted [**?**]. Conversely, Eastern cultures value interpersonal relationships and group interaction, making solitude more likely to be viewed as selfish or socially non-normative

behavior, thus exerting more negative effects on individual development [?]. However, most solitude research is based on Western cultural samples [?, ?, ?], with limited exploration in Eastern cultures. Only a few studies have examined solitude in children and adolescents in Eastern contexts [?, ?, ?, ?], leaving relatively unbalanced evidence for cross-cultural comparisons. Therefore, future research needs more evidence from Eastern cultures (including qualitative and quantitative studies) to describe and reveal how solitude is understood across cultures and how these cultural differences further influence developmental outcomes.

8.4 Digital Technology Development: Redefining Solitude and Its Development Coplan and Bowker [?] argue that solitude represents a mental state rather than a physical state, while contemporary digital technology allows individuals to be physically alone yet interact with others in virtual online worlds [?], seemingly making "being alone" an inadequate conceptualization of solitude [?]. One might ask whether solitude's definition should include various activities without social interaction, such as sleeping, playing video games, online customer service, and problem-solving [?]. Previous research found that merely expecting immediate feedback from electronic communication software can interrupt solitude [?], and Coplan et al. [?] recently focused on adolescent solitude and digital technology use, emphasizing the importance of considering digital technology when examining links between solitude and well-being. Another study found that older adults who frequently engaged in virtual interactions with others during the pandemic benefited [?]. However, only a few studies have examined how digital technology affects the adjustment functions of solitude [?, ?, ?]. Future research should therefore examine whether solitude's concept and its developmental implications for individuals across ages show new patterns and adjustment functions in the era of high-speed internet, particularly exploring online solitude in childhood and middle adulthood.

8.5 Cognitive-Neural Mechanisms of Solitude Examining solitude from a lifespan perspective cannot be separated from changes in brain structure and function. With the rise of cognitive neuroscience technology, investigating the cognitive-neural mechanisms of solitude is an indispensable part of future research. Early evidence on cognitive-neural activity in socially withdrawn children provides some indirect support, as socially withdrawn children often experience conflict between social approach-avoidance motivations [?]. One study found that socially withdrawn children showed relatively strong EEG activity in the right frontal lobe at rest, making them more prone to negative emotions and avoidance behaviors [?]. However, social withdrawal does not completely equate to solitude. Huang et al.'s [?] recent research directly examined associations between solitude motivation and approach-avoidance motivation, collecting three common neurophysiological signals related to approach-avoidance motivation (FAA, beta suppression, and PFTA) during resting-state EEG among university students aged 18-45 (M = 19.77 years). They found that solitude's neurophys-

iological basis relates only to emotional (FAA) and physical movement (beta suppression) aspects of the approach-avoidance system. Specifically, solitude preference negatively correlated with FAA, with higher solitude levels associated with relatively less left frontal asymmetry. The authors suggested this result makes it difficult to determine whether individuals who prefer solitude experience less approach-avoidance emotion or are simply less skilled at emotion regulation. Additionally, solitude preference correlated with increased beta suppression, possibly because individuals who prefer solitude have rich inner lives filled with self-reflection and creativity, mentalization that may be driven by recalling past or imagining future interactions and behaviors [**?**]. From a developmental perspective, the prefrontal cortex continues developing and maturing until age 25 [**?**]. Future research should therefore explore the brain mechanisms of solitude across different periods and the brain mechanisms underlying associations between solitude and adjustment functions across periods, to explain whether solitude has different effects on brain structure and function with age and whether different physiological indicators relate to thinking patterns and social competence across life stages, thereby providing evidence for seeking positive solitude approaches.

8.6 Practical Implications of Solitude Across Different Age Stages
From a developmental perspective, the benefits and costs of solitude differ across age stages. Accordingly, we can adopt different interventions to more effectively promote solitude's positive functions and reduce its negative effects. For children in childhood, where solitude is detrimental to social development [**?**, **?**], we can respond flexibly according to situational changes. For example, when children actively engage in solitary block-building activities [**?**], we can allow them to enjoy their solitary exploration time while encouraging solitude-preferring children to participate in peer interaction contexts. For adolescents showing high loneliness and low mental health due to lack of social interaction under the impact of digital technology [**?**], we should pay attention and encourage participation in real-life parent-child and peer interactions. Although emerging adults are busy with work and desire solitude for rest [**?**], they face another risk: being single and often alone without a partner to share leisure time [**?**, **?**]. As their key developmental task involves intimate relationships, we advocate that emerging adults should actively participate in social activities while ensuring necessary solitude time for rest and recovery. For middle-aged individuals facing work and parenting pressures and insufficient solitude, expanding family physical space proves an effective means to increase solitude time [**?**]. Additionally, a recent study confirmed that in the second half of life, positive solitude skills correlate with emotion regulation skills through music listening or mindfulness, providing implications for improving later life [**?**].

Note: Figure translations are in progress. See original paper for figures.