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早产儿语言发展的影响因素及其干预对策*

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摘要 早产儿的语言发展受到多种因素的影响，可能导致他们在词汇、语法、语音等方面出现发展滞后或障碍。本文首先简述了影响早产儿语言发展的生物学和环境因素的研究进展，其中生物学因素包括早产程度、体重和性别、新生儿发病率和疾病严重程度等，环境因素则包括新生儿重症监护室的环境、家庭中的语言环境和社会因素等。在明确这些影响因素的基础上，本文强调了早期评估和早期干预是优化早产儿语言发育效果的关键步骤，并分析了具体的干预对策，例如生理和神经干预、优化新生儿重症监护室（NICU）环境、增强家庭语言互动、多学科合作和社会支持等。此综述旨在探讨影响早产儿语言发展的各种因素，并总结出有效的早期干预措施，为其提供更为全面的语言发展支持。

关键词 早产儿，语言发展，生物和环境因素，早期干预
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早产儿是指不足37孕周出生的婴儿。每年全球共新增约1 500万早产儿，占新生儿总数1/10以上，其中近1/4会经历长期的神经发育障碍[1-2]。对于早产儿来说，语言发展异常是最常见的问题之一。大量行为研究显示，早产儿在语言发展的多个方面存在缺陷，如词汇、语法、语义、语音等[3-4]。这些异常也会对随后的学业成就和社会适应等方面的发展产生影响[5-7]。早产儿的语言缺陷在青春期乃至成年之后仍持续存在，并且可能因为执行功能和记忆相关的认知能力损伤而加剧[8-9]。因此，探寻早产儿语言发展的影响因素，并对存在语言发展缺陷风险的儿童进行早期干预，不仅有助于进一步检验和完善语言早期发展的相关理论，而且对于探索和发展具有针对性的早产儿语言促进方案具有重要的实践价值。本文旨在综述影响早产儿语言发展的各种因素，并总结出有效的早期干预措施，并对进一步的研究提出展望。

1 影响早产儿语言发展的因素

早产儿的语言发展是一个复杂的过程，受到多种内外部因素的共同作用。其中，生物学因素和环境因素都被研究证明对其有着不可忽视的作用（图1）。

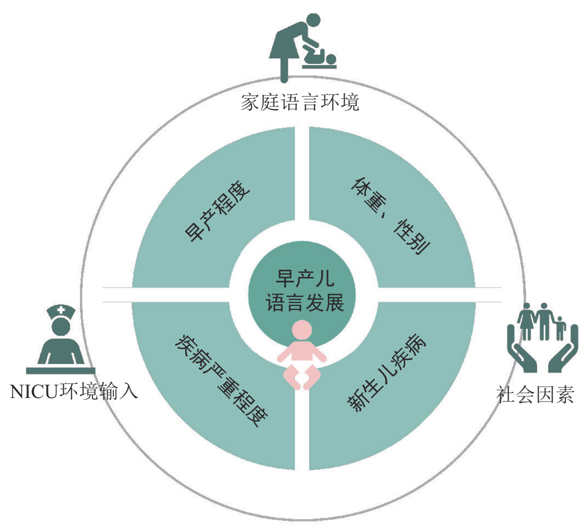

Fig. 1 Factors influencing the language development of preterm infants
图1 早产儿语言发展的影响因素

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1.1 影响早产儿语言发展的生物学因素

1.1.1 早产程度、体重、性别

胎龄作为早产儿神经发育的关键背景变量[10]，短胎龄可能对大脑发育和相关的认知、语言能力产生负面影响[11]。Foster-Cohen等[12]发现，出生时的胎龄与儿童后续语言发育存在线性关系，胎龄越小，语言能力越差，主要表现在词汇量、词汇使用、语言形态及句法复杂性方面。另有研究发现，出生胎龄为23~25周的早产儿在2岁时的认知得分低于出生胎龄为26~27周的早产儿[13]。Sansavini等[14]指出，出生胎龄小于31周的早产儿在语法发展上较出生胎龄大于或等于31周的人群更落后。

早产儿常伴随着低出生体重[15]，这与语言发展困难以及其他认知问题有关，特别是接受性词汇的发展[16]。研究发现，超低出生体重早产儿（体重低于1 000 g）会表现出显著的执行功能障碍[13]。Taylor等[17]的研究指出，11岁儿童的阅读得分与出生体重相关，体重较低儿童阅读得分较差。此外，出生体重与极早产儿（妊娠期28~32周之间出生的婴儿[18]）执行功能的认知得分被证明存在相关，有研究发现，出生体重在500~749 g的儿童比出生体重在750~999 g的儿童在2岁时的认知得分更低[13]。如前所述，早产程度和出生体重有着一定的关联[15]，而二者都表现出与早产儿语言发展的紧密关联[19]。例如，Nagy等[20]发现，围产期因素（胎龄和出生体重）对婴儿的认知表现具有显著的预测价值。具体来说，他们发现胎龄可以预测婴儿的认知发展，胎龄和出生体重共同对婴儿在2岁时的适应行为方面具有预测能力。这些结果也提示我们，早产程度和出生体重可能会交互影响早产儿的语言发展。

早产儿中，性别可能也是影响语言发展的重要因素。研究发现，男性早产儿在语言发展上可能面临更大的挑战[21]。早产女婴的词汇量等语言能力被发现显著优于早产男婴[14，22]。目前，性别差异的具体成因尚不完全明确，但研究提示可能与大脑发育的性别特异性有关[23]，并表现在大脑的结构和功能差异方面[24-25]，可能与遗传机制[26]或性腺类固醇激素[27-28]有关。这些研究为理解大脑发育和功能中的早期性别差异提供了有益的启示。

1.1.2 新生儿疾病和疾病严重程度

早产儿相较于足月儿更容易患上多种疾病[29]，其中一些疾病会显著影响其语言发展[30]。Marston等[31]指出，残疾程度、性别、出生后的住院时间和12个月时的体重等，尤其是严重残疾等临床因素，会影响2岁早产儿词汇学习，与其词汇水平呈显著相关。由于妊娠期大脑高速发育[32]，早产儿易受颅内出血、缺氧缺血性脑病和脑室周围白质软化等多种脑损伤影响[33]，可能对其语言和认知带来长期影响[34-36]。例如，围产期发生过缺血缺氧性脑病的患儿其后阶段表达性语言技能受损，持续至学龄前期，具体表现为词汇量减少、语句缩短[35]。Luu等[37]发现，严重脑损伤会对语言发展产生深远影响，尤其在接受性语言方面，存在脑损伤的早产儿词汇增长较慢。此外，早产最为常见且严重的并发症为新生儿呼吸窘迫综合症（neonatal respiratory distress syndrome，NRDS）和支气管肺发育不良（bronchopulmonary dysplasia，BPD）[38]，需长期使用呼吸辅助设备[39]。一项为期11年的随访研究发现，BPD儿童肺功能损伤长期存在[40]，进而限制其社会互动、影响语言技能和认知[41-42]。BPD与神经发育受损相关，对大脑发育和功能产生不利影响[43]。

早产儿的生理结构在许多方面都不如足月儿发育完全，这包括视觉和听觉系统[44-45]。早产儿视网膜病变（retinopathy of prematurity，ROP）是一种早产儿常见的眼部疾病，严重时可致视力丧失[46]。视觉输入对于语言发展至关重要[47]，而早产儿若患有ROP，其发生语言障碍的风险将会增加[48]。此外，早产儿听力神经系统也相对脆弱，语言易受外部风险因素的影响[49]。早产儿听力损伤可能性更高[50]，语言发展迟缓风险也更高[51-52]。在新生儿重症监护室（neonatal intensive care unit，NICU）中，早产儿可能需要接受一系列强力的治疗，如使用强效抗生素和其他药物[53]。一些药物特别是某些抗生素，如庆大霉素，在长期或高剂量使用时可能导致听力损失[54-55]。Robertson等[56]在一组1 270例体重1 250 g以上的存活早产婴儿中发现，长时间吸氧、胃肠道手术、动脉导管未闭结扎和社会经济指数低都可能影响听力水平。

可见，早产儿的发病率和疾病严重程度可能会通过多种方式对他们的语言发展产生影响。因此，对早产儿的全面评估以及针对特定疾病的早期干预至关重要。

1.2 影响早产儿语言发展的环境因素

1.2.1 NICU的环境输入

相较于足月儿，早产儿需在NICU暖箱中稳定一段时间才能回到母亲的身边，在这期间他们不仅

缺乏足够的声音和韵律信息，还需承受噪音、光线和医疗操作对其大脑和认知发展的影响[57]。Caskey等[58]量化了早产儿所处的语音环境，发现语言环境丰富的早产儿其语言能力更优。神经影像证据显示，接受较低语音刺激的早产儿的语言神经系统发展水平低于正常语言环境下的早产儿[59]。然而，尽管当前的研究已将婴儿的环境输入与其语言能力发展紧密相连，但对于这种关系背后的深层机制的理解仍有待进一步挖掘。

Pineda等[59]发现，NICU环境设置（如开放式病房和单人病房）与早产儿2岁时的神经发育显著关联。开放式病房提供丰富的声音刺激，有助于语言环境互动，凸显NICU环境声音刺激对早产儿语言发展的重要性[59]；而单人病房的早产儿的颞上沟不对称性减弱，其语言发育相对落后[60]。总体来说，NICU的环境处于两种极端时可能会造成早产儿的相对性语言剥夺。一方面，早产儿因为临床健康因素放置于过于安静的保温箱中，保温箱壁明显削弱了语音刺激，降低了获得有意义语音输入的听觉处理机会，从而可能影响语言发展。另一方面，NICU中多种不可预测的高频声音（如电子/机器、医疗操作等产生的声音）也可能导致婴儿难以接触到有意义的声音，干扰其语言发展[61]。

早产儿从温暖、黑暗、有缓冲作用的子宫水生态环境中转移到NICU的干燥、嘈杂、过度明亮的环境，这种变化本身就会对婴儿发育产生不良影响[62]。此外，NICU环境中的早产儿会面临许多潜在的压力源（如插管等医疗操作），而研究发现，NICU中压力源的暴露程度与早产儿额叶和顶叶区域的体积缩小以及颞叶内脑功能连接的改变有关[63]。

1.2.2 家庭中的语言环境

儿童的语言习得受其早期的家庭语言环境影响[64-65]。Kuhl等[64]发现，社会互动在语音学习中至关重要，婴儿通过在自然语音环境中的社会互动来学习语言。具体来说，9个月的婴儿在缺乏实时互动人声刺激的情况下，婴儿对说话者和演讲材料的关注度明显降低。基于此，社会互动在早期语言发育阶段显得尤为重要，对早产儿而言更甚。由于健康原因，早产儿需要在NICU中度过，缺乏早期社会互动和成人语言接触，这可能延迟语言发育[61]。Caskey等[66]指出，在NICU期间，父母对早产儿说话的次数与婴儿在矫正年龄18个月时的认知和语言评分存在正相关。此外，母亲在婴儿所处环境中的言语参与度也影响早产儿的语言发展。例如，Vohr等[67]发现母亲言语参与度、谈话氛围与早产儿随后18~24个月产生的单词数量相关。Lester等[68]对早产儿进行了18个月的随访，发现在母亲言语参与度高的环境中养育的婴儿在认知和语言方面得分高。

温暖、支持的亲子互动环境是早产儿认知和语言发展的重要保护因素[69-70]。Watkin等[69]指出，家庭互动模式对于患有听力障碍的儿童认知发育具有显著影响。Meijsse等[70]发现，家庭主导的干预能有效增强母婴互动，从而促进早产儿的认知发展。父母的积极参与不仅有助于婴儿的注意力集中和行为调节，还能促进自我技能的获得[71]。此外，之前的研究揭示了早产儿相比于足月儿更易受到早期成长环境的显著影响[72-73]。这一现象与早产儿较低的自我调节能力密切相关，使得他们在很大程度上依赖于照护者所提供的外部环境[72]。有研究指出，改善早产儿家庭中的亲子互动模式，能有效促进其语言发展[74]。具体来说，良好的亲子互动对促进早产儿的语音感知[75]、词汇习得[76]和口语技能[77]等多个方面的语言能力具有关键作用。这些研究结果凸显了家庭干预对于早产儿语言能力发展的重要性，特别是在提供必要的语言学习环境和认知刺激方面。

1.2.3 社会因素

社会因素是影响早产儿语言发展的重要方面，其中社会经济地位（socioeconomic status，SES）尤为关键[78]。SES包括家庭经济水平、母亲受教育程度等，影响着早产儿的成长环境、语言输入和认知刺激等，从而对语言能力产生不同效应[79-80]。

高SES家庭通常有更多资源来支持儿童发展，例如优质的教育资源、丰富的阅读材料和各种学习活动[81]。这些资源为儿童提供了更多的语言学习机会和更广阔的认知发展空间，从而更有利于其语言技能的提升[82-83]。而低SES的家庭由于资源有限、生活压力大，可能无法为孩子提供充足的语言学习环境和机会[84-87]。研究发现，低SES家庭中的早产儿在2岁时存在语言和沟通发展方面的弱势[88]。Landry等[89]通过比较早产儿（高/低疾病风险组）和足月儿发现，不仅早产和疾病风险状态可以预测语言结果，而且SES对早产儿八岁时的语言发展也有着显著影响。

母亲受教育水平与其对孩子语言发展的理解和支持有着密切的关系[90-91]。Meier等[92]发现，母

亲受教育水平能显著预测早产儿出生20个月后的语言和认知水平。这可能是因为受教育水平较高的母亲更加理解早期语言发展的重要性，并能够提供更为丰富和多样的语言环境[93-94]。她们可以有效地使用教育资源，并且能够通过阅读、讲述故事等方式与儿童进行有效的语言互动，从而有利于儿童语言技能的提升[95]。这种母子互动对于儿童的发育至关重要，尤其是对于早产儿[96-97]。

因此，社会经济地位和母亲受教育水平在早产儿的语言发展中起到了重要的作用，它们不仅决定了早产儿所能接触的语言学习机会和认知刺激的质量，还直接影响他们语言能力的形成和发展。

1.3　早产儿语言发展因素的共同影响以及其病因学探讨

早产儿的语言发展通常不是受单一因素影响，而是生物学和环境等多种因素共同影响的结果[98]。Howard等[98]对极早产儿进行了一项前瞻性纵向研究，发现新生儿时期的大脑白质密度、亲子互动的质量及母亲受教育水平共同预测了儿童之后的接受性和表达性语言能力的发展水平。Anish等[99]对影响儿童语言发展的风险因素进行了分析，发现男性性别、低出生体重、母亲受教育水平低、听力相关障碍以及语言发育迟缓家族史等因素可能会导致语言发展的不良结局。这些发现强调了生物学因素（如新生儿时期的大脑发育状况、出生时体重及性别）与环境因素（如家庭中的语言环境和母亲受教育水平）在早产儿语言发展过程中的相互作用，提示我们在进行语言发展干预时需考虑多方面因素的综合影响。

需要特别提出的是，尽管现有研究已在一定程度上探讨了影响早产儿语言能力发展的因素，但关于语言发展异常的具体病理原因仍需深入研究。一些研究指出，早产儿语言能力发展的根本问题可能源于其过早地离开了母体子宫环境，因而缺失了关键神经发育阶段所必需的母体保护[100-101]。早产中断了胎儿期神经系统的关键发育阶段，包括神经元迁移、细胞分化和神经髓鞘的形成[102]，对其大脑中控制语言功能的区域的发展造成了显著影响，进而影响语言功能的发展[103-105]。例如，Girault等[104]利用新生儿的白质连通性来预测早产儿在2岁时是否会出现认知发展滞后，准确性高达83.8%。Lee等[103]在对比极早产儿和足月儿的研究中发现，极早产儿的扣带回通路与足月儿存在显著差异，并且这种差异对预测其18~22个月的语言发展有着显著贡献。

2　早期干预对策及其对早产儿语言发展的影响

2.1　早期评估

早期评估是指尽早对早产儿进行系统的评估，确定是否存在语言发展风险或障碍，以便及时提供适当的干预措施。目前，主要的语言发展评估方法包含标准化的语言发展量表，观察儿童的语言行为和互动，以及了解家长或护理人员的观察和反馈。

研究者和临床工作者针对不同阶段的儿童，推荐使用不同的工具进行评估。新生儿时期，部分研究使用新生儿行为观察量表（Neonatal Behavioral Assessment Scale，NBAS）[106]，通过对新生儿的神经行为状态、反应能力、自我调节能力等方面的评估，判断新生儿是否存在语言发展的风险。此外，丹佛发展筛查工具第二版（Denver Developmental Screening Test II）[107]和贝利儿童早期发展量表第三版（Bayley Scales of Infant and Toddler Development-III）[108]等工具，也在评估早产儿的语言和社交技能、全面认知、语言和运动发展等方面取得了显著的效果。在儿童成长的后期阶段，专家通常使用语言发展量表（The Language Development Survey，LDS）[109]和儿童沟通检查清单第二版（Children's Communication Checklist-2，CCC-2）[110]等工具，对儿童的语言能力进行全面评估。

除了标准化的评估量表，观察儿童的日常语言行为和互动也是有效的评估手段，但需要依赖专业人员的经验和敏感度，他们会在不同环境下观察儿童的行为，看儿童是否能够理解和使用适当的语言。同时，作为儿童日常接触最多的家长和护理人员，他们对于儿童日常的行为和语言能力有着深入的理解，他们的反馈同样具有很高的价值。他们可能会被要求填写一些问卷，如父母评估早期发展量表（Parental Evaluation of Developmental Status，PEDS）[111]和儿童发育筛查（Child Development Inventories，CDI）[112]，以便从多个角度全方位地理解儿童的语言发展情况。

近年来，无创脑影像技术在临床实践中应用日益增多，为早产儿的早期评估带来了新的发展方向。医生和语言病理学家采用如ROP筛查[113]、脑干听性诱发电位（auditory brainstem response，ABR）[114]等技术完成对新生儿的初步评估，以尽

早筛查其视听力的相关问题。另外，事件相关电位[115-116]、近红外光学成像技术[117]、磁共振功能成像技术[118]等无创影像技术也被应用于语言能力的评估。这些技术的无创性质和联合使用的高灵敏度使它们成为评估早产儿语言发展风险的新兴工具。它们在预测新生儿神经发育结局方面具有重要价值，为早期干预提供了科学依据[115]。

总体来说，早期评估是早期干预的首要环节，它的有效实施能为之后的干预提供科学的依据，为早产儿的语言发展打下坚实的基础。

2.2 早期干预

早期干预是指根据早期评估的结果，为有语言发展风险或障碍的早产儿提供个性化、多学科、家庭中心的治疗和教育服务，以促进他们的语言能力和整体发展。

2.2.1 生理和神经干预策略

早产儿的生理和神经发展状况与足月儿相比有显著差异，发育相对滞后[119]。这种差异可能对其语言发展产生负面影响[120]。因此，对早产儿的生理和神经发展状况进行深入研究，以便提供更为个性化的语言发展干预策略，具有重要的实际意义。近年来，非侵入性脑刺激技术，如经颅磁刺激（transcranial magnetic stimulation，TMS）[121-122]和经颅直流电刺激（transcranial direct current stimulation，tDCS）[123-124]在一些初步研究中展现出了改善儿童语言发展的潜力。虽然目前这些技术的研究还处于初级阶段，但他们为早期语言发展干预提供了一种可能的新策略。

在早产儿中，视力和听力相关问题的出现率较高[125]，这将对其语言接收和表达能力构成直接影响。因此，采取矫正措施[126]，如进行冷凝治疗[127-128]、配备助听器、植入人工电子耳蜗[129]等来干预严重视力/听力损伤的早产儿，从而对其语言发展产生积极影响。

此外，药物和营养支持对早产儿的神经系统发育和语言学习能力有重要影响。例如，二十二碳六烯酸（docosahexaenoic acid，DHA）[130]和花生四烯酸（arachidonic acid，ARA）[131]对大脑发育起到关键作用，适当补充这些营养素可能有助于提升早产儿的语言发展。但需要注意的是，任何药物或营养支持方案都必须在医生的指导下进行。另外，母乳喂养不仅可以提供早产儿所需的营养和免疫物质，还可以增进母婴之间的亲密关系，促进早产儿的社会情感发展和语言交流能力[132]。

2.2.2 环境改善策略

a. NICU环境的改善

在NICU住院期间，根据早产儿的年龄和临床状况的个性化发展护理和互动对早产儿的发育至关重要[133]，并且护理质量会影响婴儿的语言发展[134]。NICU环境的多项临床改进措施中，婴儿发展性照顾护理已被证明对新生儿的成长有显著的积极影响。此模式不仅关注婴儿发育，也优化其生存环境，旨在为早产儿提供舒适、低刺激的照护环境，模拟母体子宫中的条件[135-136]。Heidelise等[133]发现，NICU住院期间为低危早产儿提供的个性化护理对其神经发育具有明显的正面效应，这一积极影响持续到矫正年龄9个月。这为同类早产儿的长期发育前景带来了乐观的预期。Montirosso等[137]发现，NICU中接受低质量发展性护理的极早产儿比高质量发展性护理的极早产儿表现出更低的单词和句子理解分数。并且，在高质量发展性护理的NICU环境下，极早产儿和足月儿没有语言发育差异。Scala等[138]的研究指出，在NICU进行的护理中，接受护理的早产儿在语言得分上高于未经护理的，且在护理过程中给予的有针对性的语言刺激可以进一步提升其得分。综上所述，NICU中的发展性护理的质量对于增强早产儿的语言技能具有显著效果。

b. 亲子互动的促进

在NICU环境中，与父母的互动在早产儿语言发展方面也具有显著意义。由于早产需要一定时间的住院治疗和NICU的护理操作，早产儿在出生后损失了部分和母亲的声音联系的机会[139]。近年来研究表明，家长更多参与到NICU的护理中能显著降低婴儿的压力暴露，其中母乳喂养及皮肤接触护理（如袋鼠护理）可以有效减轻婴儿的压力和疼痛体验[140-141]。Vanderveen等[142]研究了父母参与的早期干预措施，包括父母教育、个体化发育护理及家访等，发现这些措施在短期内为早产儿带来了积极的临床效应。早期的经历能快速改变发育中大脑结构，引导其沿着不同的发育路径前进，干预措施旨在尽量减少NICU环境带来的压力。

家庭参与是干预模式中的关键因素，对儿童的词汇和语言能力发展有显著影响。有学者对不同年龄段的儿童进行综合性干预，发现较高的语言分数与早期的干预相关，高质量的家庭参与和正向的语言发展结局密不可分，如果可以早期进行积极的家庭参与，会更加有利于婴儿语言结局的成功实

现[143]。另外，干预的时间点也会影响语言发展的结果，例如12个月前入组的儿童在3岁时评估的词汇量和语言得分比后入组的儿童高[144]。但值得注意的是，家庭积极参与可以在一定程度上抵消较晚开始干预的不利影响。研究发现干预过程中，语言能力发展速度快的儿童，其家庭参与度往往最高，这一现象再次凸显了家庭参与在干预措施中的核心地位[145]。

2.2.3 其他干预方式（以音乐训练为例）

除了传统的干预方式，目前部分医院的NICU已开始为早产儿提供特殊的综合性支持[146-148]。证据表明，音乐及其他感官刺激能显著推进早产儿语言和认知发展[149-153]。研究揭示，音乐训练可以改变大脑皮层组织模式[154]。例如，Schlaug等[155]发现，音乐训练不仅增强儿童语言能力，还使相关脑区灰质体积扩大。鉴于婴儿大脑的高度可塑性，音乐干预在婴儿期对早产儿的语言发展尤为有益。

研究发现，音乐倾听干预对听觉处理有积极影响，能促进儿童听觉皮层发育。Trainor等[156]将4个月婴儿随机分到吉他/马林巴琴音色组，结果显示，婴儿对训练了的音色敏感性增加，相应的听觉事件相关电位也有所增强。另外，如果音乐训练融合积极的社交环境，而非仅仅是被动地听录音，对儿童的全面发展更为有利[157]。例如，播放玩具音乐并伴随父母摇摆，可以更吸引婴儿注意。

除了正式音乐课程训练外，日常音乐活动对婴儿的语言发育有益。近年来研究发现，无论是系统的音乐训练或是家庭、学校的日常音乐活动，都能有效推进听觉神经的发育，对语言发展风险较高的婴儿具有积极作用[158-159]。Corrigall等[160]证实音乐训练能增强阅读及语音处理水平。一个针对9个月大婴儿的音乐干预研究[161]指出，此类干预可增强婴儿对音乐和语言时间结构的神经处理，表现为音乐训练后听觉事件相关电位的增强。Williams等[162]的研究结果进一步揭示，增加家中的音乐活动能有效提升婴儿的社交技巧和词汇积累。总之，音乐和其他感官刺激为早产儿及处于发展风险的儿童的认知和语言发展指明了方向。

3 总结与展望

早产是一个重要的公共卫生问题，不仅对婴儿的身体健康构成威胁，而且对婴儿的神经发育和语言发展产生深远影响。早产儿语言发展受多种因素影响，形成了一个复杂的影响网络，其中包括生物因素和环境因素等。在生物因素中，早产儿的生理及神经发育对其语言技能有直接影响[97]。环境因素，特别是早期生活环境（如NICU），以及与父母和其他人的互动，为语言学习奠定了基础[68，95]，另外家庭的经济条件、教育资源等也会对其语言发展产生影响[84，92]。这些因素之间相互联系，共同影响早产儿的语言进展。

对早产儿的语言发展，早期干预起到了至关重要的作用。为了更精准地帮助他们，进行早期评估是必要的，这能及时发现并评估其是否存在语言发展的风险，进而提供恰当的干预。例如，早产儿的听觉感知在新生儿时期即可用事件相关电位等方式进行早期筛查[163-164]。深入了解早产儿的生理和神经状况，并给予适当的干预，是取得良好效果的关键[165-166]。此外，优化NICU环境[59，138]和家庭中的语言互动[58]，为他们创造更多的语言学习机会也很重要。在干预过程中，多学科的合作和社会支持同样不可或缺。展望未来，应进一步研究生物与环境因素如何相互作用，影响语言发展，并不断验证不同干预策略的效果，以为早产儿提供更为科学和有力的支持，确保他们健康、全面地成长。

尽管已经取得了一些成果，但早期干预策略在早产儿语言发展中的应用仍需进一步研究和完善。首先，需要更多系统性和长期的研究来评估不同干预策略的效果，特别是其长期影响和可能的副作用。其次，需要更加深入地理解早产儿语言发展的机制，以便设计更加有效的干预措施。此外，还需要探索更多的合作机会，例如，加强医疗、教育、社会服务等部门的协同，以实现更全面和高效的早期干预。

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Factors Influencing The Language Development of Preterm Infants and Their Intervention Strategies*

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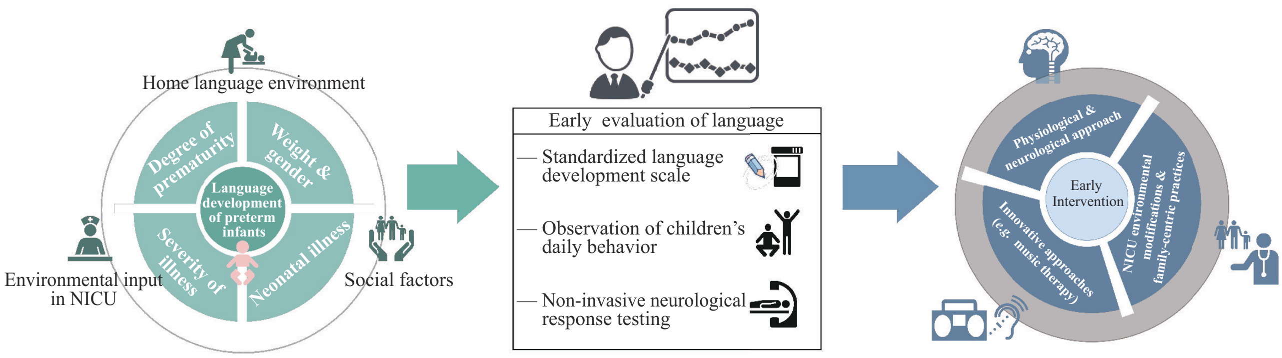
Graphical abstract



Abstract Preterm infants, born before 37 weeks of gestation, represent a significant portion of newborns globally, many of whom experiencing long-term neurodevelopmental disorders. Language development anomalies are common among preterm infants, often leading to deficits in vocabulary, grammar, phonetics, and semantics, which can persist into adolescence and adulthood. Given these complexities, these developmental challenges necessitate a deeper understanding of the influencing factors and the importance of early intervention. Biological factors such as the degree of prematurity, birth weight, and gender significantly impact language development. Specifically, shorter gestational age and lower birth weight are associated with language difficulties, manifesting in restricted vocabulary, syntax, and grammatical complexity. In addition, the severity of neonatal illnesses, including intracranial hemorrhage, hypoxic-ischemic encephalopathy, and bronchopulmonary dysplasia, critically impact cognitive and language development. Equally important, sensory systems, particularly vision and hearing, are also crucial for language acquisition, for example, retinopathy of prematurity (ROP) may increase the risk of language disorders. Environmental factors also play a vital role in language development of preterm infants. The environment within neonatal intensive care units (NICU), while important for the survival of preterm infants, can inadvertently impose sensory challenges, thereby influencing neurodevelopmental outcomes, including language skills. Beyond the NICU environment, the domestic setting and familial interactions emerge as crucial determinants. Variables such as the parental educational background and socioeconomic status substantially

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influence the extent and quality of language exposure, thus shaping the linguistic development of preterm infants. Addressing these challenges requires comprehensive early intervention strategies. This includes deploying a range of early evaluation tools, encompassing standardized language development scales and observational techniques, to promptly identify infants at risk of language delays. Recent advances in non-invasive brain imaging techniques, such as event-related potentials and functional magnetic resonance imaging (MRI), have opened new horizons in early detection and intervention planning, providing critical insights into the neurodevelopmental status of these infants. Intervention strategies are diverse and integrate physiological and neurological approaches, environmental modifications, and family-centric practices. Physiologically, addressing sensory impairments and nutritional needs is fundamental to fostering robust language development. This involves interventions like sensory stimulation therapies and nutritional supplements rich in essential brain-development nutrients. Additionally, environmental optimization, particularly in NICU settings, to replicate the protective conditions of womb is crucial for enhancing language learning. Strategies include controlled auditory and visual stimulation and implementing developmental care models. Furthermore, family involvement is equally important. Encouraging active parental engagement and fostering language-enriched interactions are crucial. Notably, innovative approaches such as music therapy have shown promise in enhancing auditory processing and language skills. These interventions utilize the infant brain's neuroplasticity, combining auditory stimulation with social interaction, thereby enriching the developmental environment for preterm infants. In summary, the language development in preterm infants is shaped by an intricate interplay of biological and environmental factors, requiring a multifaceted and early intervention approach. As our understanding evolves, the integration of medical, educational, and social services will be critical in providing holistic support for the healthy development of these infants. Future research efforts should aim to elucidate the underlying mechanisms of language development in preterm infants and to refine intervention strategies to ensure more effective long-term outcomes.

Key words　preterm infants, language development, biological and environmental factors, early intervention
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