

## 《心理学报》审稿意见与作者回应

题目：多阶段混合增长模型的影响因素：距离与形态

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### 第一轮

审稿人 1 意见：

意见 1：本文是一项比较前沿的研究，有一定的理论意义，也有潜在的应用价值。但目前文稿还有如下问题：研究目的的描述还不够明确。而且，“Tolvanen(2007)采用模拟研究的方法探讨了 GMM 的参数(如潜在类别、测量信度等)对模型估计精度的影响，结果发现潜在类别距离影响分类的准确性：距离越近，其分类结果越差。Steinley, D. 和 Brusco, M. J (2011a, 2011b, 2011c)比较了聚类分析(K-means Clustering)和混合模型(Mixture Model)在潜在分类上的差异，并探讨了潜类别间的重叠性对分类结果的影响。”一段放在这里不甚合适，应当前移到文献综述或者问题提出部分。建议改成将“尚未可知”改成“尚不清楚”。

回应：感谢审稿专家的建议。已经将这一段内容移入了“1.2 模型的参数估计和应用”部分，先针对参数估计中的问题进行集中讨论，再对模型的应用做出综述(详见修改稿 p.3)。另外，按照专家建议将“尚未可知”改为“尚不清楚”(详见修改稿 p.4)。

意见 2：有的数学符号表述欠妥或这不够规范：例如方程 1 和 2 及其解释，要区分矩阵及其元素，不要混为一谈。而且，当向量的分量下标是时间  $t$ ，那么向量就与  $t$  无关了。又如，式子(4)右边应当是向量的分布吧？最后，公式中所有字母都要有定义或者解释。

回应：非常感谢老师详细的审阅和修改建议。本文在公式表述方面的确有一点问题，把元素和矩阵混用了。现在根据老师的建议，已将所有的公式进行了统一，将公式 1, 2 做了修改，公式 4 加入了分布的说明。在文章中用蓝色字体标出(p.2, 3, 5, 7)。

意见 3：1.2 节，“对于加速发展、减速发展等非连续发展趋势”，是发展不连续还是发展速度不均匀？加速发展和减速发展，不见得不连续吧？

回应：感谢老师的提醒。本文这里有一定的歧义。一般意义而言，加速、减速发展(二次型)的确并非不连续。为了避免产生歧义，已经将文中原来的表述改成了“对于发展速度的突变，可以通过定义不同阶段的时间函数来描述和估计(p.3)”。

意见 4：图 2 下面一行，“可以根据公式 11”，文中引用远在后文的公式不好，而且似乎与公式 11 无关？

回应：抱歉原文此处引用错误，不是公式 11，而是公式 7 (p.6)，已在文中改正。

意见 5：文中有的句子不够通顺，例如，摘要中“(4)随着潜类别间距离的越大和样本量越大，参数估计精度越高。”

回应：感谢审稿老师提醒。在文中已经修改核对(如摘要中“潜类别距离和样本量越大”。p.1)

审稿人 2 意见：

意见 1：This manuscript aimed to answer several questions related to PGMM (1) in what conditions do the PGMM and LCGA come up with similar results, (2) how to select an

appropriate model, and (3) how do the distance of latent class and the pattern of the growth trajectory influence the parameter estimation by conducting a simulation study. The design of the simulation study (i.e., a two-class and two-period model and a 3 (sample size) x 3 (distance of x 4 (pattern of growth trajectory) model conditions) was appropriate in addressing the above questions. The simulation results were promising and these results suggested several implications about the use of PGMM models in the analysis of longitudinal data. First, the distance of the latent class is an important factor in determining the accuracy of model selection and parameter estimation regardless of the PGMM or LCGA model. When the distance of latent class is small, applied researchers should be cautious about the results. Second, it was suggested that the appropriate sample size for the PGMM model should be greater than 200 in general. Third, the pattern of growth affects the model selection at which unparallel growth pattern generally led to better model estimations compared with parallel pattern. Fourth, compared with PGMM model, LCGA were less accurate in parameter estimations even though its performance of model selection is similar to PGMM. Finally, ARI provides a good index for model selection. Based on these results, this manuscript has considerable contribution to the methodology for the analysis of longitudinal data by providing some specific conditions at which the interpretation of the PGMM results is appropriate.

Overall, considering the quality of the results and implication of this manuscript, I will recommend the publication of this manuscript in this journal. However, there are several issues that I think the author(s) may consider so as to strength this manuscript for publication:

In this study, a two-class-two-period model was used in the simulation study. I wonder if a three-class model, which is considered to be more general, should be included in the simulation study as well. One advantage of including a three-class model is that we can investigate if the results may become different under conditions when the distance of the class are the same across different classes or when two classes are closer, whereas the third class are further apart from the other two classes. The author(s) have mentioned this issue as one of the future directions for research. I think it is worth extending the simulation study to three-class model in the current study so as to strengthen the conclusion drawn in this manuscript.

回应：我们非常赞同审稿专家的意见和建议，本研究得到的结论是否可以推广到三类或更多类的确是非常有意义的话题。根据专家的建议，我们在原文中增加了一个补充的研究（考虑到文章的篇幅和结果的相似性，简化了影响因素的水平数），来探讨结论的可推广性，结果发现得到的结论和两类一致（详细修改见修改稿 3.4[p.8]和 4.3[p.13]）。

意见 2：The author(s) have compared PGMM and LCGA throughout the study. The results have suggested that LCGA is not as reliable as PGMM most of the time. It seems to the readers that PGMM is preferred in all situations. I think the author(s) should give some more descriptions about when it is realistic or practical to assume there are no individual differences among the people within each class so that a simplified model (i.e., LCGA) is preferred over the PGMM model.

回应：感谢您的建议，在讨论部分增加了一段关于 LCGA 模型选择和应用上要考虑的问题，以及可能的优势。详见讨论部分第四段的内容。（p.14-15）

意见 3：As suggested from the simulation study results, distance of latent class is an important factor in influencing model selection and parameter estimation. A practical question is how can

applied researcher determine the distance of the latent class as large, medium and small in their own study? In this study, distance of latent class is defined as SMD. In practice, is there any guideline or recommendation that help applied researchers to determine the size of the distance of latent class so that they know if the interpretation of the results is appropriate or not. The author(s) may have one or two sentences in addressing this issue.

回应：根据专家的意见，在研究展望部分增加了对这一问题的讨论，详见 5.3 中的第三段。（p.16-17）

意见 4: Another interesting issue about PGMM and LCGA is if the size of parameter also influences the model selection and parameter estimation. In the current study, size of parameter is not a manipulated factor in the simulation study. The author(s) may add a paragraph in the future direction section and explain if the size of parameter may influence the estimations and whether future studies should explore on this factor.

回应：同意专家的意见，在研究展望部分增加了对这一问题的讨论，详见 5.3 中的最后一段。（p.17）

意见 5: The author(s) should proof-read the manuscript, for example,

Line 1, p. 6 “ 可以根据公式 11” , I suppose it is 公式 7.

In short, this manuscript is clear and concise in addressing the objectives as stated by the author(s). With minor revision, this manuscript is ready for publication. I hope the above comments are useful.

回应：回复：感谢您的提醒，原文中引用公式编号错误，已经作了修改，应该是公式 7. (p.6)

## 第二轮

审稿人 1 意见：

意见 1: 在摘要中考虑去掉“Piecewise growth mixture modeling, PGMM”，后面的正文中有说明已经足够；

回复：感谢审稿老师的建议。在摘要中去掉赘述部分。（p1）

意见 2.作者也承认“加速、减速发展（二次型）的确并非不连续”（见审稿意见（一）的第 3 点意见），但目前文中还有多处类似情况存在：(1)在 1.1 节中，“该模型假设观测群体同质和发展趋势连续。如果存在发展趋势不一致的多个群体，也就是存在潜在的类别(unobserved heterogeneous)；抑或发展趋势不连续，存在多个增长趋势不同的发展阶段”。趋势连续？趋势一致？还是趋势相同？目前的行文，似乎将这些混为一谈了。(2)在 1.2 节中，“PGM 用于解决发展阶段不连续的问题，对于发展速度的突变，可以通过定义不同阶段的时间函数来描述和估计；GMM 用于解决发展趋势不同质的问题”，这里出现了“连续”、“突变”、“不同质”来形容。

回复：非常感谢审稿老师的问题。GMM 处理不同质、PGM 处理不连续。为了减少歧义，规范专业词汇用法，我们已经将文中不相关的词汇修改过来。比如，“如果存在发展趋势不同质的多个群体，也就是存在潜类别、未观测到的异质性(unobserved heterogeneous)，抑或发展趋势不连续(不能用一个连续函数表达)，即存在多个发展阶段。”（p1）

意见 3.在 1.2 节中，“一类错误大小”建议改为“第一类错误率”。

回复：已经在文章中修改。(p3)

意见 4.第 2 节中，“PGMM 的引入是基于 GMM 和混合模型”，这里混合模型是 PGM 还是另有所指？在 1.2 节中说：“PGMM 是混合增长模型(Growth mixture modeling, GMM)和多阶段增长模型(Piecewise growth modeling, PGM)的综合模型”。

回复：文章中修改成“PGMM 的引入基于 GMM 和 PGM，所以 GMM 与 PGM 的影响因素”  
(p4)

意见 5.代表变量的英文字母用斜体，矩阵、向量用粗斜体。

回复：将公式 1~14 全部重新修订。

意见 6.文中的图形最好是用白色背景。

回复：将所有的文中插图全部修订。

意见 7.英文摘要有待打磨。

回复：将英文摘要全部重新修改。(为方便阅读，英文摘要未用红色字体标出)。