A Large Language Model-Based Analysis of Authorship of the Pauline Epistles

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1 Abstract

This paper contributes to the ongoing discourse on the authorship of the Pauline epistles by employing a semantic analysis of the verses within these letters. The study aims to provide a data-driven perspective that complements traditional historical and textual criticism methods. By analyzing the most distinctive verses in the disputed epistles and identifying close matches in those epistles known to have been written by Paul, this approach offers new insights into the authorship question. The findings generally align with the scholarly consensus but present challenges to it in certain areas, suggesting alternative interpretations of Pauline authorship.

2 Introduction

The Pauline Epistles form a foundational component of the New Testament, shaping Christian theology and ecclesiastical instruction. Traditionally, thirteen epistles have been attributed to Paul the Apostle, yet scholarly consensus varies regarding the authenticity of several of these letters. The determination of Pauline authorship has profound implications for biblical interpretation, historical theology, and the understanding of early Christian communities. Despite the current popularity of Large Language Models (LLMs), driven by ChatGPT and other widely used LLM-based AI services, we are not aware of any research on Pauline authorship which performs semantic analysis using LLMs.

3 Literature Review

3.1 Traditional Authorship Attribution

The Pauline Epistles, comprising thirteen letters, have long been considered a cornerstone of the New Testament canon. Historically, these epistles were attributed to Paul the Apostle, a seminal figure in early Christianity whose

missionary work and theological insights significantly shaped the nascent church. Early church fathers, such as Irenaeus, Clement of Alexandria, and Tertullian, affirmed Pauline authorship of these letters, drawing on historical traditions and internal textual evidence. They assessed authorship based on factors like style, theological consistency, and historical context, believing these epistles to be authentic communications from Paul to various Christian communities and individuals.

However, this traditional attribution has been scrutinized and questioned over the centuries, especially with the advent of higher biblical criticism in the 18th and 19th centuries. Scholars began to apply more rigorous historical and literary analyses to the texts, leading to a more nuanced understanding of authorship that sometimes diverged from traditional views.

3.2 Modern Scholarly Perspectives

In contemporary biblical scholarship, the debate over the authorship of the Pauline Epistles remains vigorous and unresolved. Scholars typically divide the epistles into three categories: the undisputed letters, the disputed letters, and the pastoral letters. We assign probability values of 0.95 for the undisputed Pauline letters and 0.05 for the extremely unlikely pastoral letters. Within the disputed letters we assign p=0.7 for the probable letters and 0.3 for the unlikely letters. These values are useful proxies for the scholarly consensus and help to provide a first level of plausibility for our methodology by assessing the correlations of the methodology with the consensus (while still allowing novel insights as we will see later in our discussion of the results).

Undisputed Letters: The seven epistles widely accepted as genuinely Pauline are Rom., 1 Cor., 2 Cor., Gal., Phil., 1 Thess., and Phlm.. These letters exhibit a consistent theological perspective, writing style, and historical context that align well with what is known of Paul's life and ministry. Of those however, we are treating only the first four (Rom., 1 and 2 Cor. and Gal.) as certain (probability 0.95), and the other as probable (and hence subject to analysis).

Disputed Letters: The authorship of Eph., Col., and 2 Thess. is debated. These letters present certain stylistic and theological differences from the undisputed epistles. For example, Eph. and Col. contain more developed ecclesiological and christological themes that some scholars argue reflect a later period than Paul's lifetime. However, others suggest these differences could be due to varying purposes, audiences, or secretarial influence. We treat these epistles as unlikely to have been written by Paul with a probability of 0.3.

Pastoral Letters: The pastoral epistles (1 Tim., 2 Tim. and Tit.) face the greatest skepticism regarding Pauline authorship. Critics point to significant deviations in vocabulary, style, and church structure described within these letters, which appear more aligned with second-century Christian communities than the first-century context of Paul's ministry. Supporters of Pauline authorship argue these variations can be attributed to different recipients and situations or possibly to Paul's use of an amanuensis. We start with the assumption that the

pastoral letters are highly unlikely to have been written by Paul (probability 0.05), but we still analyze their authorship with this methodology.

3.3 Methodologies Previously Employed to Determine Authorship

Traditional methods for determining authorship include textual criticism, historical criticism, and literary analysis:

- Textual Criticism: Scholars compare the earliest available manuscripts
 to identify textual variants and establish the most likely original text.
 Differences in vocabulary and style between letters are analyzed to infer
 authorship.
- 2. **Historical Criticism**: This approach examines the historical context of the letters, considering factors such as the social, political, and theological environments of the early Christian communities. It assesses whether the content of the epistles aligns with what is known about Paul's life and mission.
- 3. Literary Analysis: Scholars analyze the literary style, structure, and rhetorical techniques used in the epistles. Consistency in these elements across different letters is often seen as indicative of common authorship, while significant divergences may suggest otherwise.

More recently, computational methods such as stylometry and semantic analysis have been employed to supplement traditional approaches. Stylometry involves the quantitative analysis of writing style, using metrics like word frequency and sentence length to compare texts. Semantic analysis, the focus of this paper, goes further by examining the meanings and relationships of words and phrases within the texts to identify patterns indicative of a single author or multiple authors.

This literature review highlights the complexity and ongoing nature of the debate over the Pauline Epistles' authorship. Traditional and modern methodologies each contribute unique insights, yet no single approach has definitively resolved the question. This study aims to enhance the discourse by applying a novel semantic analysis algorithm, based on Large Language Models, to re-examine the authorship of the epistles attributed to Paul, offering a fresh perspective on this enduring scholarly issue.

4 Our Methodology

The semantic analysis approach we are taking specifically seeks to first identify the "most distinctive verses" in underlying meaning of a *target epistle* which we are investigating to determine its true authorship. These verses express a meaning not *generally found* in the rest of the Old or New Testaments (including other Pauline Epistles). To do this we generate *embeddings vectors* generated by Large Language Models (LLMs) which express the underlying meaning of those verses. We then find those verses are most distinct (have the greatest average cosine distance) from all other Biblical verses.

Once we have the distinctive verses for the target epistle we then compare with an epistle known to be written by Paul, such as Romans. We look for matches for the "most distinctive verses" in the target epistle to the known Pauline epistle. We then average the distance scores of the closest match in the source epistle for each of the most. This average distance is then a measure of the likelihood of Paulinity for that target epistle.

4.1 Justification for Using Semantic Analysis

Paul wrote his epistles over a long period of time and to various geographic and demographic audiences. He was an educated scholar and effective communicator, and was known to modulate his style and tone for these diverse recipients. This makes stylemetric analysis alone of limited value in determining true authorship of controversial dubious epistles.

Paul was also a theological innovator for the time, with ideas not present or less emphasized in other New Testament texts (such as "justification by faith alone" and "union with Christ"). His core innovative ideas are expressed in various styles and language, but remain central in his writings. Because of this phenomenon, taking the distinctive verses from a target text and comparing it with known Pauline work is a powerful complementary method to stylometric and textual analysis to establish true authorship.

4.2 Data Selection and Pre-processing

For our analysis, we selected four epistles widely accepted as genuinely Pauline—Rom., 1 Cor., 2 Cor., and Gal.—as the source texts for comparison. We generated semantic embeddings vectors for each verse in these epistles using the GPT-40 model with the "text-embedding-ada-002" LLM, a state-of-the-art tool for capturing the underlying meaning of textual data. These vectors were then stored in vector database (specifically Weaviate) for rapid retrieval and computation.

The target epistles, whose Pauline authorship is under question, were similarly processed. Distinctive verses from these epistles were identified based on their cosine distance from all other verses in the Bible, with higher distances indicating more unique content. Cosine distance is an inverse score of the semantic distance between two verses, based on the values present in each of the embeddings vectors. Low distance means high similarity.

4.3 Analytical Algorithm

For each "target epistle" which we are analyzing for Pauline authenticity, we provide a succession of known-certain Pauline epistles as the "source epistle" to compare against. First we find the top 20% most distinctive verses in the target

epistle. This threshold is somewhat arbitrary, but many of the epistles are quite short (for example, 2 Thess.is 47 verses) so the threshold cannot be much lower and still give us meaningful amounts of sample verses to work with.

As mentioned, "distinctiveness" is measured primarily by the average cosine distance of the verse from all other Old Testament and New Testament verses. But we also want verses of a certain complexity to be favored. We don't want semantically uninteresting verses to be used in our analysis. So the algorithm gives a complexity score and uses that to boost the original average distance. Specifically the complexity is computed as the variance of the vector (normalized to between 0 and 1) and then multiplied by 0.05. This weighting factor allowed complexity of the verse to be weighted roughly equally to to the average distance of the verse vectors from other Biblical verses. As a point of future investigation, we could evaluate various weighting factors to see which produce the strongest correlations with scholarly consensus.

Thus distinctive verses are those which have a certain amount of complexity and that are still distant from most other Biblical verses. We also screen out the first two and last two verses of the epistle as, for most of the Pauline epistles, these "greeting and closing" verses have relatively low semantic meaning.

Using this algorithm, then take the set of distinctive verses for each target epistle and compare against the source epistle and find the closest match single verse in the source epistle, along with its cosine distance. We then average the cosine distance scores for the most distinctive verses of the target source epistle. This average of closest distance for each distinctive verse is the effective score of the target epistle versus the source epistle. For ease of interpretation, we then normalize each source epistle's scores against the target epistles to values between 0 and 1.

The source text could potentially be simplified to all known Pauline epistles. However the more fine-grained epistle by epistle analysis (with results presented in the next section) allows us to garner more detailed subtle insights.

4.4 Source Code for Reproducibility

The detailed results are broken down in the following section. The source code is available at $https://github.com/adamblum/pauline_semantics$. Specifically it is the script compare_books_distinctverses.py invoked as follows:

python comparebooks_distinctverses.py source_epistle target_epistle

If you choose to try to reproduce these results, please write to me for the Weaviate vector database credentials to put into your environment to execute the tests. This should be the only dependency that you have on external infrastructure.

Target Epistle	Prob.	Source			
		Rom.	1 Cor.	2 Cor.	Gal.
Phil.	0.7	0.2880	0.1736	0.2643	0.1007
1 Thess.	0.7	0.0392	0.0868	0.0000	0.0000
Phlm	0.7	0.4036	0.0000	0.3292	0.4595
Eph.	0.3	0.0768	0.0705	0.1421	0.0025
Col.	0.3	0.2610	0.1302	0.2868	0.0786
2 Thess.	0.3	0.2301	0.2658	0.6334	0.2482
1 Tim.	0.05	0.5479	0.3544	0.8180	0.3538
2 Tim.	0.05	0.5660	0.4774	0.3791	0.4300
Tit.	0.05	0.2301	0.3852	0.5736	0.4373
3 Corinthians	0	0.4711	0.5099	0.7431	0.3440
Laodiceans	0	0.0000	0.1248	0.3067	0.0811
ActsPaulThecla	0	1.0000	1.0000	1.0000	1.0000

Table 1: Semantic Distance Analysis of Distinctive Verses

5 Results

5.1 Overview of Findings

Table 1 shows the results of each of the disputed target epistles compared against the undisputed epistles. The "target epistle" is the epistle we are attempting to determine the authentic Paulinity of. The "source epistle" is the undisputed Pauline epistle that the distinctive verses of the target epistle are compared against. he values are normalized for each source epistle (column) between 0 and 1 (hence there will always be a zero for the closest match target and a 1 for the most distant target). The score normalization removes the need to check all values against the mean and standard deviation to interpret them. Low scores, following the algorithm described above, indicate probable Pauline authenticity.

Ephesians had close matches of many of its more distinctive verses with all of the known Pauline epistles. 1 Thess., already generally thought to be Pauline, had extremely close matches of its distinctive verses to all known Paul epistles. Acts of Paul and Thecla and 3 Corinthians were quite distant in their distinct verses from all the known Pauline epistles, as befits their status as pseudoepigrapha. We will walk through specific examples of some of the closer semantic matches in the Discussion section.

5.2 Correlation with Scholarly Consensus

The probability column is an indicator of the scholarly consensus, described shortly. We list the undisputed epistles as only Rom., 1 Cor., 2 Cor. and Gal. We list Phil., 1 Thess. and Phl as probable. While we expect the analysis to further buttress the authenticity of these epistles as well, we want to provide as much value to the scholarly debate as possible. And there has been some

limited debate on the Paulinity of these last three epistles.

Also among the deutero-Pauline epistles we break them into two categories: "unlikely" (Eph., Col. and 2 Thess.) and "very probably not" (the pastoral epistles of 1 Tim., 2 Tim. and Tit.). Consider these four categories as a summary of the scholarly consensus. We assign the probability of undisputed as 0.95, likely as 0.7, unlikely as 0.3 and "very probably not": as 0.1. To help with correlation analysis we added probabilities for the pseudoepigrapha of 3 Corinthians, Laodiceans and the Acts of Paul and Thecla as probability 0.

The correlation coefficients between the cosine distance scores and the scholarly consensus probabilities discussed were as follows:

• **Romans**: r=-0.454

• 1 Corinthians: r=-0.823

• 2 Corinthians: r=-0.705

• **Galatians**: r=-0.395

These results indicate a strong negative correlation between the LLM-generated semantic distance scores and the consensus probabilities, particularly for 1 Cor. and 2 Cor.

5.3 Interpretation of Findings

The statistical analysis revealed significant alignment between the LLM-based semantic distances method and traditional scholarly consensus, supporting the validity of this novel approach. Additionally, the method identified Ephesians as more likely to be authentically Pauline than current scholarly consensus suggests, a finding that warrants further investigation.

The distinctiveness and complexity of the selected verses played a crucial role in this analysis, providing a nuanced understanding of the epistles' authorship. The statistical negative correlation between LLM-generated distance scores and scholarly consensus enhances the credibility of this method as a supplementary tool for biblical authorship studies.

5.4 Breakdown of Disputed Epistles

Moving through each of the disputed epistles from most to least likely according to consensus, below are our conclusions as to authorship, based on the results presented in **Table 1**: **LLM Semantic Similarity Analysis of Distinctive Verses**.

Note that we are not analyzing the four undoubted Pauline epistles (Rom., 1 Cor., 2 Cor. and Gal.) as they are used as the "source epistles" to measure "true Paulinity".

5.4.1 Likely Pauline Epistles

For the likely Pauline epistles (Phil., 1 Thess. and Phlm) the results buttress the likely Paulinity. In particular, there are very low distances (more than one standard deviation below the mean) when comparing 1 Thess. to Rom., 2 Cor. and Gal. Phlm had very close matches of its distinctive verses to 1 Cor.

5.4.2 Deutero-Pauline Epistles

For the Deutero-Pauline epistles that are not pastoral (Eph., Col. and 2 Thess.) the method provides strong indications that Eph. is probably Pauline. There are low average cosine distances of all distinctive Eph. verses against all of the certain Pauline epistles (Rom., 1 Cor., 2 Cor., and Gal), as shown in the Eph. row of Table 1.

5.4.3 Pastoral Epistles

For the pastoral letters (1 Tim., 2 Tim, and Tit.) that very few believe are written by Paul, the closest match distinctive verse distance scores are all high (well above the mean distance of other distinctive Pauline verses to known Pauline sources). The distinctive verses method thus provides no reason to actively challenge the scholarly consensus that these are pseudonymous.

5.4.4 Pseudoepigrapha

As an additional check that the algorithm is not producing "false positives", we include three known forgeries: 3 Corinthians, Laodiceans, and Acts of Paul and Thecla. Acts of Paul and Thecla had the highest distances for its distinct verses of any target. It is worth mentioning that this is not an epistle so perhaps this is not surprising. 3 Corinthians also had very high distances for its distinctive verses.

Laodiceans distance scores are low, but its worth noting that Laodiceans is quite short. So the top 20% of distinctive verses is only three verses. It is difficult to draw many conclusions from such a small dataset. It may be appropriate to remove Laodiceans from analysis.

6 Discussion

As we saw in the Results section, the evidence for the true Paulinity of 1 Thess. and Eph. via LLM semantic analysis is very strong. Though the opinion that 1 Thess. is authentically Pauline is part of the mainstream consensus, it still provides a good example of compelling results of the distinctive verses-closest matches distance method. For Ephesians the consensus leans toward its non-Paulinity. We believe that the method discussed adds strongly to the discussion of Ephesians and its authenticity. In this section we will walk through a couple examples from these books that show perhaps more concretely how the semantic similarity is determined.

6.1 Semantic Analysis Examples

To illustrate more concretely this method step by step, let us examine some of the more distinctive verses from Ephesians and 1 Thessalonians to show why the method so strongly indicates Pauline authorship.

6.1.1 Ephesians 2:20

One example of remarkable similarity in ideas is Eph. 2:20:

having been built on the foundation of the apostles and prophets Jesus Christ Himself being the chief cornerstone,

Compare this to 1 Corinthians 3:11:

For no other foundation can anyone lay than that which is laid which is Jesus Christ.

They are quite similar in meaning, with a (non-normalized) cosine distance of 0.101, which is remarkably close. Peter also speaks of building the church on the cornerstone of Christ (Peter 2:4-8). And of course Jesus says of Peter "on this rock I will build my church" (but doesn't say that he is himself the cornerstone). That aside, this metaphor is not particularly common among other NT authors or later theologians. For Paul (and Peter) though the mechanics of building out the church were of course daunting and all-consuming. The image of Christ as the cornerstone was presumably reassuring and foundational (pun intended) for them.

6.1.2 Ephesians 1:22

Another distinctive Pauline concept is the idea that Christ is the ruler of all things in the church and in the coming world after his return, and that this power was conferred on him by God the Father. Eph. 1:22:

And He put all things under His feet and gave Him to be head over all things to the church,

1 Cor. 15:27 says:

For ""He has put all things under His feet."" But when He says ""all things are put under Him" it is evident that He who put all things under Him is excepted.,

Here Paul explains the not particularly simple concept more explicitly and at length. But the meaning is quite similar, as exhibited by a non-normalized cosine distance of 0.1143.

6.1.3 Ephesians 1:5

As another example of semantic similarity, Eph. 1:5 is quite distinctive and on the conceptually complex side.

having predestined us to adoption as sons by Jesus Christ to Himself according to the good pleasure of His will

It is similar in meaning to Rom. 8:29:

For whom He foreknew He also predestined to be conformed to the image of His Son that He might be the firstborn among many brethren.

In both of these he emphasizes God's plan that believers should be sons of God in a family following the example of Jesus. Even more significantly both passages present the uniquely Pauline concept that the believers free choice towards salvation is actually known by God ahead of time - "predestined".

The non-normalized cosine distance of the embeddings vectors for these statements is just 0.1215. This metaphor is not common elsewhere in the Bible. While the specific language and style used in the two verses is quite different, the concepts here are distinctively Pauline.

6.1.4 1 Thessalonians 3:12

One of the most distinctive verses in 1 Thess. is 3:12. Its distinctiveness "raw score" (average distance from all Biblical verses) is 0.2647, the fourth most distinctive verse in 1 Thess.

And may the Lord make you increase and abound in love to one another and to all just as we do to you

This is similar in meaning to Romans 15:5.

Now may the God of patience and comfort grant you to be like-minded toward one another according to Christ Jesus

In both of these he is exhorting the readers to increase the love towards each other as they have seen Paul and/or God do to them. In 1 Thess. 3:12, Paul is the example to copy. In Romans 15:5, God is the example. It is not quite identical in meaning but it is quite close in saying "love each as we (Paul or God) do to you". The non-normalized cosine distance of the embeddings vectors is 0.1168.

The imperative to increase their brotherly love following an example is a distinctive Pauline concept that doesn't appear often in other epistles or elsewhere in the Old or New Testaments. The average distance of this verse from other verses is 0.2647 which is the fourth most distinctive verse in 1 Thess. Note that the distinctness score also uses the "complexity" of the verses in determining its distinctness. Although this is not the greatest distance verse from other Biblical verses, it is one of the more complex ones, in the top 20% of more complex verses in 1 Thess.

6.1.5 3 Corinthians 1:14

As an example of a pseudoepigrapha verse that is distinctive and distant from true Pauline epistles, the most distinctive verse in 3 Corinthians is 1:14:

and that Christ came not down in the flesh, neither was born of Mary This is a distinctly un-Pauline (and, some might say, un-Christian) concept. The closest match to any verse's embeddings vector in Romans is not very close at all, Rom. 1:3:

concerning His Son Jesus Christ our Lord who was born of the seed of David according to the flesh

Of course, this is easy to recognize as not close without a Large Language Model to assist, but the non-normalized vector distance supports the dissimilarity at 0.151 (well above the average vector distance of verses compared to Romans).

6.2 Theological Significance

Since the Pauline authorship of Ephesians is the most challenging to the consensus, the indication of its Paulinity is probably the most significant contribution to the discussion of epistle authorship. Ephesians is full of foundational Christian theological ideas, expressed in a much more general (seemingly not to a person or a specific audience) way than other epistles.

There are several theological principles present in Ephesians that are otherwise either not covered or not discussed in depth by other New Testament authors. One of the most fundamental is the mysterious tension between human free will to choose faith and God's foreknowledge of what our choice will be (and thus who will be saved). This is something only Paul has centered on amongst the New Testament. Peter and John mention this but it is not central to their writings.

The emphasis of sexual morality and the proper relationship of husband to wife is another theme of Ephesians that occurs frequently in other genuine Pauline epistles and figures prominently in Ephesians.

The exhortations to love one another as God and Jesus do for the believer is also more common in Paul. If Ephesians is Pauline, the re-emphasis in Ephesians that Christ is the head of the church and that power was granted to him by God puts this doctrine more firmly into one of Paul's innovations versus other early apostles (although this particular doctrine appears elsewhere of course).

Ephesians is a pithy (just 155 verses) yet poetic and exultant statement of most of the more central concepts of Christian theology, and still manages to cover some of the more intermediate concepts important to already-believers in the church. Romans is also an excellent primer on the foundational Christian concepts, but perhaps more targeted to new or not yet believers, and with a more explanatory tone, style and length (433 verses). The drastically differing styles show Paul's extraordinary range. Yet the remarkable consistency of ideas evidences Paul's dogged determination to inculcate and develop his churches' faith and understanding of important theological concepts through whatever style and means are necessary. LLM-based semantic analysis seems to be a useful tool to demonstrate the consistency of his dogma and cut through the noise of stylometric analysis of his adept and varied rhetoric.

7 Conclusion

7.1 Summary of Key Findings

Semantic similarity analysis using Large Language Models is a powerful method of determining true authorship of epistles by finding verses similar in meaning, especially among more distinctive verses.

There is strong evidence that Ephesians was written by Paul based on low distance scores of Ephesians more distinctive verses from the certain-Pauline epistles. 1 Thess. also has close distance scores of its distinctive verses, although most scholars already agree that 1 Thess. is Pauline.

7.2 Future Research

Further statistical refinement could include analyzing the distribution of cosine similarity scores to identify outliers or employing advanced machine learning techniques to predict authorship probabilities directly from the embeddings.

We would like to repeat these results in the original koine Greek. LLM embeddings vectors may not be as high quality in this language, but we still believe it is a worthwhile validation step.

Finally, we want to explore further the objections to the Paulinity of Ephesians more specifically to see if LLM-based semantic analysis can shed any light on those problem areas within Ephesians.

7.3 Final Thoughts

We believe that LLM-based semantic analysis is a powerful tool to examine some of the more contentious authorship questions present in the New Testament. Stylometric analysis has severe limitations for such questions, especially given the stylistic diversity evidenced by Paul. We hope that this is just the first of many New Testament investigation topics where LLM semantics can add to the scholarly debate.

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