T-Model Fingerprint Calculator

FAQs

Henry Templeman

Question: What is the T-Model?

Answer: The T-Model is an interactive, open source, online mathematical model for fingerprints which defines discriminating values (rarity or specificity) for fingerprint ridge features based on type and position, defines reductions factors for reduced levels of clarity and quality of agreement, and using formula estimates the conservative (upper bound) number of fingerprint close matches or "look-alikes" present in a given population group. The T-Model infers a fingerprint match when the number of look-alikes present in the relevant fingerprint population is less than 1.

Question: How does the T-Model compare to conventional ACE-V methodology, which is currently used and supported by the broad fingerprint community?

Answer: The formula used in the T-Model Fingerprint Calculator is essentially a "best guess" for how the nature of fingerprints behave in terms of how many look-alikes will be present in a given population group. It makes predictions that are testable which is the key to science. The concept of making a guess for a formula that endeavors to describe an aspect of nature, and then comparing the results of the computation to data from experiment is key to science (e.g. This is described by Richard Feynman in the YouTube video "Richard Feynman Key to Science" here.) *ACE-V on the other hand is not a formula. It does not calculate anything. It does not make predictions that are testable. That is the biggest difference between the two methods.*

Question: Has the T-Model been tested?

Answer: To date a total of 47 well-controlled and reproducible experiments have been performed by Henry Templeman (CLPE) that corroborate the ability of the T-Model to make conservative (upper bound) estimates for numbers of look-alikes present in a given fingerprint population. Links to the data from these experiments are on the web site www.facts.mynetworksolutions.com.

Question: To what degree has the T-Model been tested by the fingerprint community?

Answer: Upon initial online publication of the T-Model in 2008 the T-Model was sent to the IAI, SWGFAST and FBI for review, independent validation study and testing. Since that time, none of these organizations have performed testing on it.

Question: If the T-Model has not been tested by IAI, SWGFAST or FBI, then can it be used in criminal casework?

Answer: If a latent print examiner(s) performs well-controlled, reproducible, honest experiments, and if the data from these experiments corroborate that the T-Model does what it claims it can do, then there is foundation to use it in criminal casework. It is important that the data from the examiner's experiments is well documented and that the examiner is prepared to speak to the operations of the T-Model Fingerprint Calculator, if necessary in court.

Question: Why does the T-Model make conservative estimates for number of look-alikes in a fingerprint population?

Answer: The T-Model is designed for criminal casework. As a result, the values for ridge feature types and ridge feature positions have been designed to be slightly conservative (i.e. rounded down to a nearest whole number, quarter value, etc.) in order to be slightly conservative on behalf of the defendant. In additional the estimates for numbers of look-alikes present in given fingerprint populations have been designed to be slightly conservative (upper bound) on behalf of the defendant.

Question: What roll does the examiner play in the evaluation phase of the exam?

Answer: The examiner plays no roll in the evaluation phase of the exam. It is the T-Model that infers a fingerprint match, not the examiner.

Question: How can the T-Model Fingerprint Calculator be applied to criminal casework?

Answer: The T-Model Fingerprint Calculator can be used to 1) Support latent print examiner findings, 2) Challenge latent print examiner findings, 3) Replace the latent fingerprint examiner to evaluate the suitability of latent fingerprints for comparison, and/or 4) Replace the latent print examiner to evaluate sufficiency (or insufficiency) of matching ridge features in two fingerprints to infer identification.

Question: Can the T-Model be applied to palm prints?

Answer: No. The T-Model is designed only for fingerprints.

Question: In some cases the T-Model can infer fingerprint identification based on only 1 or 2 matching ridge features. How is that possible?

Answer: The T-Model defines discriminating values for ridge feature types and ridge feature positions. Different ridge feature types have different values. Similarly different ridge feature positions have different values. For example a trifurcation is a rare ridge feature type and therefore it has high discriminating value. Similarly, a ridge feature located 9 intervening to its nearest Level II neighbor is also very rare which means it also has high discriminating value. In fact, it is extremely rare. For example, consider the presence of only 1 ending ridge not in a funnel (i.e. value = 14.25) located nine (9) intervening ridges from its nearest Level II neighbor (i.e. value = 908,970,832). Most examiners would not recognize the immense discriminating value that such an amount of "empty space" has. Provided there is excellent agreement between these two clusters of ridge features, the T-Model estimates there are 0.09 look-alikes in a California Department of Justice AFIS database containing 100 million fingers. In other words based on this population group the T-Model would infer a fingerprint match. This is a characteristic of the T-Model that provides examiners with a basis for the intuitive knowledge they have gained through experience for estimating the discriminating value of corresponding "empty space" in two fingerprint impressions.

If the above amount of ridge detail, i.e. a single ending ridge not in a funnel with 9 intervening ridges to the nearest neighbor, in a latent print was found to be in excellent agreement with an exemplar fingerprint, then based on a fingerprint population of 100 million (i.e. equal to California Department of Justice AFIS database), then the T-Model would estimate there are less than 0.09 look-alikes and as a result infer an identification.

Question: How does the T-Model identify dots?

Answer: See the following link:

http://web.archive.org/web/20120818063340/http://www.henrytempleman.com/discriminating_value_for_ridge_feature_types_13

Question: What are the standards and controls concerning the operation of the T-Model?

Answer: The standard for the T-Model to infer a fingerprint match is clear: The estimated number of fingerprint look-alikes present in the relevant fingerprint population must be less than 1. This is clear, unambiguous and subject to testing.

The operations of the T-Model Fingerprint Calculator are controlled by Spreadsheet Converter, which converted the calculator from its original Microsoft Excel spreadsheet format to the present interactive online format. This new interactive online format has been tested and it has been found to perform the designated mathematical operations correctly. The T-Model directs users to calibrate the calculator prior to use to insure it operates as intended. The formulae, values and mathematical operations used by the T-Model are fixed, transparent, and subject to review and critical scrutiny. This information can be viewed online under the T-Model Fingerprint Calculator "Legend" at the following website: www.facts.mynetworksolutions.com.

Question: Latent fingerprints recovered from crime scenes are more reflective of flat fingerprint and not rolled fingerprints. What types of fingerprints were used in the experiments that form the basis of the T-Model?

Answer: Flat fingerprints are more consistent with latent prints recovered from crime scenes than rolled fingerprints. As a result, only flat fingerprints from ten-print records were used in the T-Model experiments.

Question: How does the T-Model define a fingerprint look-alike?

Answer: The T-Model defines a fingerprint look-alike as a cluster of ridge features similar in shape and position in which the nearest neighbors of each corresponding ridge feature falls within a ±20 percent friction skin elasticity stretch and/or compression threshold and a ±10 degree rotational threshold. The experimental data that was used to define these thresholds is available for review under the web site located at: www.facts.mynetworksolutions.com.

Question: Does the T-Model have a known or potential error rate?

Answer: There are a number of different ways to define error rate. For example, the calculator uses mathematical operations originally formatted in Microsoft Excel and converted (and powered by) by [Spreadsheet Converter](). These operations have been tested and found to operate without error. As with any endeavor involving humans the potential for clerical error exists, i.e. examiners clicking on wrong values, which as a result produce different calculations and potentially incorrect evaluations. The T-Model addresses this issue by making each analysis and comparison assessment for each individual ridge feature used by the examiner clear, fixed, and transparent for purposes of review and critical scrutiny.

The ability of the T-Model to make correct decisions (i.e. establish correct inference for identification) was tested against 5 of the largest and best known fingerprint look-alikes ever found as a result of an AFIS search which included the most notable erroneous fingerprint identification ever made (i.e. the erroneous fingerprint identification made to Brandon Mayfield by the FBI). In each case the T-Model was not fooled into identifying the amount of matching ridge features present in the look-alikes as sufficient to infer identification. In addition the T-Model was tested 100 against identifications made by expert latent print examiners at the San Jose Police Department (i.e. The identifications made by examiners were assumed to be correct). The T-Model corroborated each of the 100 identifications as correct. As a result, it may be said that, so far, the current error rate for the T-Model to make a false identification is zero. For additional information, go to the Internet Archive Wayback Machine for www.henrytempleman.com on August 18, 2012 here to review details regarding the error rate studies performed and their results.

It is significant to mention that of all the previous error rate studies ever performed by any person(s) in the fingerprint community, not one considered the relevant population variable of possible subjects, or utilizing extremely small numbers of ridge features (i.e. 1, 2, 3, 4 or 5), and not one considered the variable for different numbers of intervening ridge counts to nearest neighbors, i.e. "empty space". In addition it appears that all testers for previous fingerprint experiments failed to realize that if one wants to test an idea, then the tester must have no presumptions. It must be as if the tester is from Mars and knows nothing about the subject. That means one starts with zero ridge features, then 1, then 2, then 3, and so on, and then for population groups of 1, then 2, then 3, and so on, and then for areas of empty space of 0 intervening ridges to a nearest neighbor, then 1, then 2, then 3 and so on. All testers appeared to have failed to do this.

Question: Can AFIS be used to test the T-Model?

Answer: So far no AFIS has demonstrated the ability the accurately find small clusters of ridge feature present in a given population group. For example, clusters of 4, 5 and 6 ridge features from known records were searched using different AFIS manufacturers. In every case AFIS failed to reliably find the match or even to put the original search sample in the top 10 list of candidate respondents. Until AFIS is shown to reliably find such small clusters of ridge features, we are limited to manual testing which means using small clusters of ridge features in small population groups.

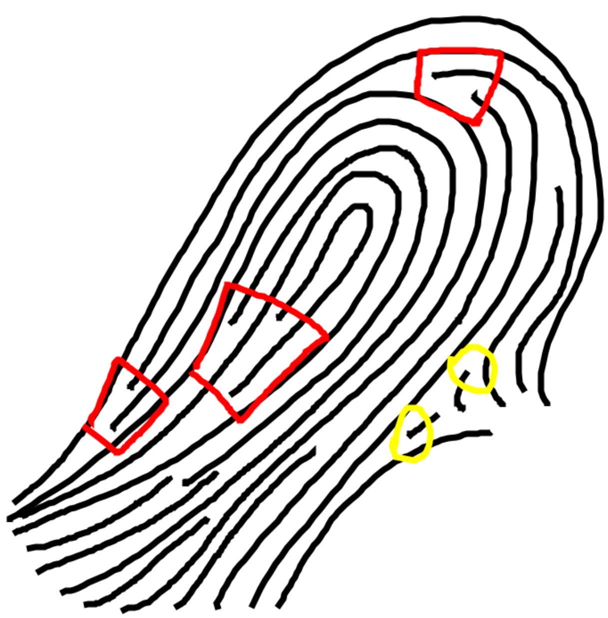
Question: What makes the T-Model more accurate at making fingerprint evaluations than expert latent print examiners?

Answer: The T-Model estimates the conservative (upper bound) number of look-alikes present in a given fingerprint population. Expert latent print examiners were tested to make similar estimates and the results showed that the T-Model was on average 7-8 times more accurate than expert latent print examiners. In addition latent print examiners who are unfamiliar with the largest and best look-alikes ever found by AFIS tend to be fooled into making erroneous identifications. For example, 17 latent print examiners were presented with the Chesapeake IAFIS look-alike. 41% of the examiners were willing to identify that look-alike as a positive identification and testify to that identification in court. Using conservative assessment values, the T-Model calculated the amount of matching ridge features as insufficient to infer identification.

Question: What is a funnel?

Answer: A funnel is an area of friction skin subjected to pattern forces causing directional ridge features, e.g. ending and bifurcating ridges, to point in the same direction. For additional information see "Pattern Force" under 7.6.1 and 7.6.3 at:

http://www.latent-prints.com/images/IEEGF2.pdf



The direction for the ending ridges in funnels (red) and ending ridges between delta type lines (yellow) is predictable and therefore bear the same discriminating value.

Question: How does the T-Model mathematically define a funnel?

Answer: The length of the top of the funnel (X) should be greater than or equal to half the length of the longest side of the funnel (Y). The formula used to define diminishing area funnels is as follows:

$X \geq Y/2$

where,

X = length of funnel's top
Y = length of funnel's longest side

For additional information see "Pattern Force 1 of 2" and "Pattern Force 2 of 2" under snapshot version 9.2 published by the Internet Archive Wayback Machine on August 18, 2012 here, *or click the following links:*

Pattern Force 1 of 2
http://web.archive.org/web/20120818063357/http://www.henrytempleman.com/pattern_force_12

Pattern Force 2 of 2
http://web.archive.org/web/20120818064500/http://www.henrytempleman.com/pattern_force_22

NOTE: If there is any doubt as to whether or not a ridge feature is in a funnel, then for purposes of conservatism, the ridge feature defaults to a ridge feature in a funnel, i.e. the ridge feature bearing the lower discriminating value.

Question: Has the T-Model been published?

Answer: The T-Model was first published online at www.henrytempleman.com in 2008. Since that time it was modified and refined based on data from experiments. Snapshots of the T-Model at archived on the Internet Wayback Machine. The latest version of the T-Model on that web site is archived on August 18, 2012 here.

Question: Has the T-Model been subjected to peer review?

*Answer: The T-Model has been submitted for review to the International Association for Identification (**IAI**), presented to members of **SWGFAST**, and requested for review by numerous members of the law enforcement community including the **FBI Latent Print Support Unit**. As of this posting (August 15, 2013) the T-Model has not been refuted or falsified by any member(s) of any of these organizations, or by any other person(s) or organization(s). Comments were submitted to the author regarding the T-Model (see next page).*

“Great work on a needed sufficiency research and robust probabilistic model.”

John Clark
Western Identification Network
SWGFAST Member
3/18/2008

"Your model can certainly assist in generating good outcomes and underpinning results...Your model has the advantage over other models that it establishes the weight/value of a mark on itself by calculating the chance of existence of a look alike."

Arie Zeelenberg
Senior Fingerprint Advisor
National Police Force of the Netherlands
3/7/2010

"You have a lot of information of which I would like my own staff to be aware. I am impressed with your use of the T-Model. This is an example that I believe in and would very much like to see developed and embraced by the Latent Community."

Roy Marzioli
Manager Central Identification Services
Forensic Services Division
Contra Costa County Office of the Sheriff
5/19/2009

“I have read through several of your later revisions and thought it was really well written and based on sound science and statistical computation/theory.”

Karen Salamy
Software Engineering Tech
Monterey Bay Aquarium Research Institute
3/11/2008

“There are some really strong ideas here. I also think that you are joining a growing group of examiners that are thinking outside the box and recognizing the need to appropriately weight the corresponding features. I like the initiative of this.” And, “You are approaching this from a frequentist point of view, rather that Bayesian— which is fine—but changes the framework of the propositions and can lead to a few problems, but these can be avoided.”

Glenn Langenburg
CLPE, PhD Candidate, SWGFAST Member
Minnesota Bureau of Criminal Apprehension
12/24/2007 and 1/1/2008

"I would like to request a copy of your T-Model Fingerprint Calculator for review. I appreciate your efforts in advancing the friction ridge analysis discipline through innovative research that seeks to allow scientists to communicate their results more effectively."

Aaron J. Uhle
Major Incident Program Manager
Latent Print Support Unit, FBI Laboratory
August 2012

Question: How does the T-Model speak to the criticism of fingerprint analysis by the National Academy of Science report: *Strengthening Forensic Science in the United States: A Path Forward (see NAS Report)?*

Answer: Below are statements in the NAS Report followed by the T-Model response.

Statement 1 (Page 141)

"Latent print examiners report an individualization when they are confident that two different sources could not have produced impressions with the same degree of agreement among details. This is a subjective assessment."

T-Model Response

Although a latent print examiner is required to perform the fingerprint analysis and comparison (i.e. input c=values for ridge feature and make qualitative assessments) it is the T-Model that makes the final decision, which is objective and does not reflect the decision by the examiner, if any.

Statement 2 (Page 141)

"There has been discussion regarding the use of statistics to assign match probabilities based on population distributions of certain friction ridge features. Current published statistical models, however, have not matured past counts of corresponding minutia and have not taken clarity into consideration."

T-Model Response

The T-Model uses statistical data gathered as a result of 47 fingerprint look-alike experiments that are published and archived online. In addition to calculating a fingerprint match probability for a given arrangement of ridge features present in a given population group, the T-Model takes clarity as well as quality of agreement into consideration and defines qualitative metrics for each.

Statement 3 (Page 142)

"Claims of 'absolute' and 'positive' identification should be replaced by more modest claims about the meaning and significance of a 'match." (Jennifer Mnookin)

T-Model Response

The T-Model establishes an "inference" for a fingerprint match, which corresponds to a verbal statement such as "the probability the two fingerprints are from the same source borders on (is near) certainty" which means, although remote, there is always for a look-alike to occur. The T-Model uses numerical estimates to define what is the probability for a fingerprint look-alike to occur in a given fingerprint population. The numerical estimates are clear and the final evaluations are unambiguous.

Statement 4 (Page 142)

"Although there is limited information about the accuracy and reliability of friction ridge analyses, claims that these analyses have zero error rates are not scientifically plausible."

T-Model Response

Although the T-Model has yet to be fooled by a fingerprint look-alike into making an erroneous fingerprint "match", the possibility clearly and always exists. In addition, since the T-Model depends on human examiners to assess and input values during the analysis and comparison phases of an exam, it is plausible that examiners will at times 1) not follow guidelines and make inappropriate assessments, 2) make incorrect measurements, 3) input wrong numbers, or 4) make clerical errors. What distinguishes the T-Model from all other models and the current ACE-V method is that all of the values and assessments made by the examiner (i.e. all areas where the above 4 errors can be made) for each and every ridge feature used during the exam, are clearly shown and made transparent by the T-Model format, which makes them subject to review and critical scrutiny.

Statement 5 (Page 142)

"ACE-V provides a broadly stated framework for conducting friction ridge analyses. However, this framework is not specific enough to qualify as a validated method for this type of analysis."

T-Model Response

Unlike ACE-V, the framework for the T-Model is designed such that it can be independently tested, i.e. the conservative (upper bound) estimates it makes for numbers of look-alikes present in a given fingerprint population, and decisions to infer identification, can be corroborated or falsified by independent experiments. In order for the T-Model to be considered a "validated" method for fingerprint examination, it should be tested to see if it does what it claims it can do. If the results from independent testing show that the T-Model does do what it claims it can do, then it may be considered a valid method.

Statement 6 (Page 142)

"ACE-V does not guard against bias; is too broad to ensure repeatability and transparency; and does not guarantee that two analysts following it will obtain the same results. For these reasons, merely following the steps of ACE-V does not imply that one is proceeding in a scientific manner or producing reliable results."

T-Model Response

The T-Model guards against bias by eliminating human decision-making from the final decision, i.e. it is the T-Model that infers a fingerprint match, not the examiner. The T-Model uses fixed numerical values for specific ridge feature types and positions with guidelines to assess ridge feature clarity and quality of agreement. All values, assessments and formulae are transparent and subject to critical scrutiny. Provided the input values for the analysis and comparison phases of the exam are the same, and provided the input value for the relevant population for the case at hand is the same, the T-Model guarantees that the evaluation will be the same for all users.

Statement 7 (Page 143)

"We have analysed the ACE- V method itself, as it is described in the literature. We found that these descriptions differ, no single protocol has been officially accepted by the profession and the standards upon which the method's conclusions rest have not been specified quantitatively. As a consequence, at this time the validity of the ACE-V method cannot be tested." (Haber and Haber)

T-Model Response

The standards upon which the T-Model's conclusions rest have been specified quantitatively, i.e. inference for a fingerprint match is established when, and only when, the number of fingerprint look-alikes present in the relevant population is less than 1. As a consequence, the validity of the T-Model is transparent , testable and subject to critical scrutiny.

Statement 8 (Page 143)

"Better documentation is needed of each step in the ACE-V process or its equivalent. At the very least, sufficient documentation is needed to reconstruct the analysis, if necessary. By documenting the relevant information gathered during the analysis, evaluation, and comparison of latent prints and the basis for the conclusion (identification, exclusion, or inconclusive), the examiner will create a transparent record of the method and thereby provide the courts with additional information on which to assess the reliability of the method for a specific case. Currently, there is no requirement for examiners to document which features within a latent print support their reasoning and conclusions."

T-Model Response

T-Model entries reflect a clear, transparent record of the examiner's analysis and comparison of each ridge feature used during the exam. This record can be checked against T-Model guidelines to insure appropriate values and assessments were input. The final evaluation based on the relevant population input, as well as the final evaluations based on fingerprint population groups ranging from 100 to 1 trillion, are clear and unambiguous which provides the courts with additional objective information on which to assess the reliability of the T-Model for a specific case.

Statement 9 (Page 144)

"Uniqueness and persistence are necessary conditions for friction ridge identification to be feasible, but those conditions do not imply that anyone can reliably discern whether or not two friction ridge impressions were made by the same person. Uniqueness does not guarantee that prints from two different people are always sufficiently different that they cannot be confused, or that two impressions made by the same finger will also be sufficiently similar to be discerned as coming from the same source. The impression left by a given finger will differ every time, because of inevitable variations in pressure, which change the degree of contact between each part of the ridge structure and the impression medium. None of these variabilities—of features across a population of fingers or of repeated impressions left by the same finger—has been characterized, quantified, or compared."

T-Model Response

The T-Model has been tested against the largest and best fingerprint look-alikes ever recorded, and based on conservative analysis and comparison assessments for clarity and quality of agreement, it has not been fooled (so far) into making an erroneous identification. In each case the T-Model quantified these fingerprint look-alikes as bearing a discriminating value insufficient to infer identification.

Statement 10 (Page 144)

"To properly underpin the process of friction ridge identification, additional research is also needed into ridge flow and crease pattern distributions on the hands and feet. This information could be used to limit the possible donor population of a particular print in a statistical approach and could provide examiners with a more robust understanding of the prevalence of different ridge flows and crease patterns. Additionally, more research is needed regarding the discriminating value of the various ridge formations and clusters of ridge formations. This would provide examiners with a solid basis for the intuitive knowledge they have gained through experience and provide an excellent training tool. It also would lead to a good framework for future statistical models and provide the courts with additional information to consider when evaluating the reliability of the science."

T-Model Response

Based on data gathered as a result of 47 close match experiments, the T-Model defines the discriminating value for 15 of the most common ridge feature types and 11 of the most common ridge feature positions. The T-Model also uses formula to estimate the discriminating value for clusters of ridge features. The T-Model takes under consideration ridge flow in the process of fingerprint analysis by differentiating between directional ridge features impacted by pattern force, i.e. core area, delta areas, and ending and bifurcating ridges located in a funnel and not in a funnel. The T-Model uses this information to limit the possible donor population of a particular print and provides examiners with a more robust understanding of the prevalence of different ridge feature types and positions within different ridge flows. In addition this information provides examiners with a solid basis for the intuitive knowledge they have gained through experience and provides an excellent training tool.

<u>Statement 11</u> (Page 144)

"Currently, distortion and quality issues are typically based on "common sense" explanations or on information that is passed down through oral tradition from examiner to examiner. A criticism of the latent print community is that the examiners can too easily explain a "difference" as an "acceptable distortion" in order to make an identification."

<u>T-Model Response</u>

The T-Model requires the user to document differences and distortions observed in latent and exemplar fingerprints and to apply the appropriate reduction factors. The qualitative assessments made by the user regarding differences and distortions observed in latent and exemplar fingerprints are recorded in the T-Model Fingerprint Calculator, transparent and subject to critical scrutiny.

Question: Why has the T-Model not been tested by individual examiners?

Answer: It seems that the reason it has not been tested is due to either lack of funding, time, and/or interest. Also, historically fingerprint examiners were never educated about the importance of experiment to learn about fingerprints. The way fingerprint analysis developed over a century ago was not based on testable formula that endeavored to emulate the natural behavior of fingerprints and the propensity for look-alikes to occur in a given population group. Unlike other sciences, a culture of science never developed for fingerprints. For example, when a new formula is presented in, for example physics, which claims to describe the behavior of a natural phenomenon, there are many interested persons within the field that test the formula to find out if it does what it claims to can do. It is an exciting thing for scientists to test newly proposed laws or formula because it may result in a new insight or explain something about the nature of a phenomenon that was previously unknown. Unlike fingerprint examiners, scientists realize that nature speaks in terms of mathematics and that the task is to find laws or formula that nature speaks in with regards to a particular phenomenon. With regards to fingerprints, the propensity for look-alike arrangements of ridge features to occur in a given population group is a phenomenon of nature. The T-Model is a formula that endeavors to explain how nature behaves in that regard. Currently there are no formulae or calculations used for fingerprint analysis that have been accepted by the broad fingerprint community. This is what the T-Model is introducing to the field. It is important to add that currently there appears to be little understanding by persons in the IAI, SWGFAST and FBI of the fact that extended experiments have been performed that corroborate the ability of the T-Model to make fairly accurate conservative (upper bound) estimates for numbers of look-alikes present in a given population group. The data from these experiments represents the empirical content that gives the T-Model its predictive power. ACE-V has no empirical content and therefore it has no predictive power. As a result the T-Model method to evaluate fingerprint evidence is better than ACE-V because it has greater empirical content, and hence greater predictive power (i.e. For Karl Popper "any theory X is better than a "rival" theory Y if X has greater empirical content, and hence greater predictive power, than Y."

Question: I would like to apply the T-Model to criminal casework. How can I test it to find out if it does what it claims it can do?

Answer: The T-Model can be tested by taking a small cluster of fingerprint ridge features and a large number of visually clear exemplar flat fingerprints selected a random from ten-print files and then use count the number of similar clusters (i.e. look-alikes) that exist. For example, in a flat fingerprint population of 1000 the T-Model estimates there will not be more than 40 look-alikes. The author performed 3 experiments with 3 different clusters of 3 ending ridges in a funnel. The number of look-alikes found was 30, 33 and 39. He average was 34. If you do a similar experiment, and if you see similar findings, then you have corroborated the T-Model to do what it claims it can do. You simply need to do the experiments.

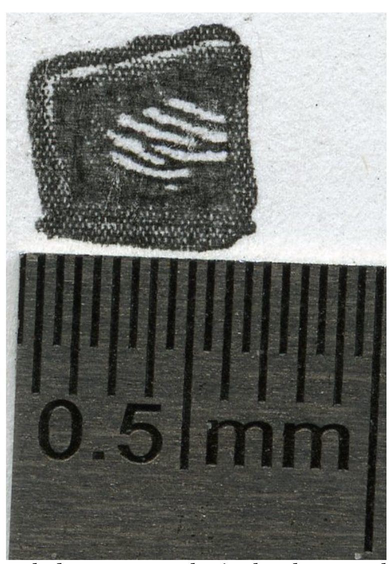
Example

Take a cluster of 3 ending ridges in a funnel and search how many look-alikes are present in a fingerprint population of 1000 clear flat fingerprints selected at random. It is important the flat fingerprints are visually clear, with no smudges, heavy deposition distortion, and so on. That is the only filter that should be used. Take a close-up photograph of the cluster and print an enlargement of it out for purposes of review and archival. Be sure to include a millimeter measurement scale in the photo, e.g. a 0.5 mm ruler is preferred. Borderline look-alikes should be carefully measured. If the measurements fail to agree with friction skin elasticity thresholds (±20% stretch or compression and 10 degrees rotational threshold, then it is not a look-alike and should be counted. Repeat this experiment 3 times with 3 different arrangements of 3 ending ridges in a funnel.

Repeat the experiment for 3 ending ridges not in a funnel.

Repeat the experiment for 3 bifurcations in a funnel.

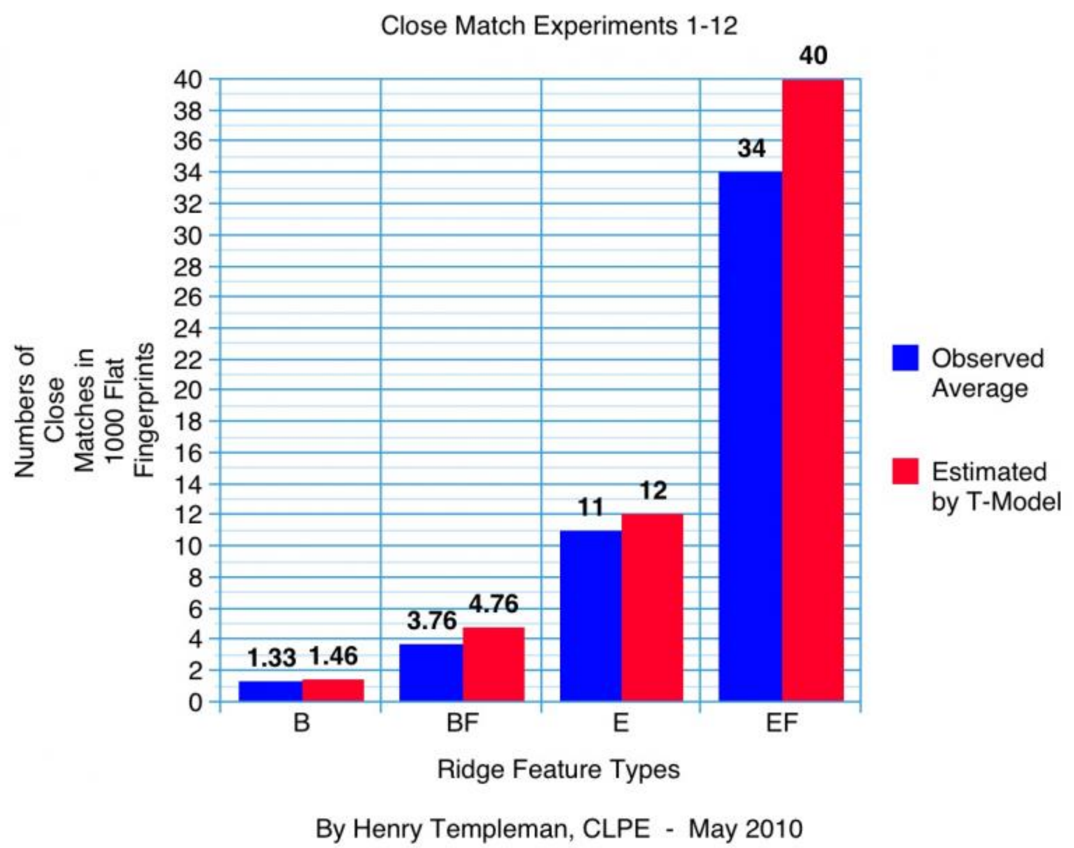
Repeat the experiment for 3 bifurcations not in a funnel (see below sample images).



Include a 0.5mm ruler in the photograph

3 bifurcations not in a funnel simplified for easy searching

If the observed data from these 12 experiments agrees with the data from experiments performed by the author, then the T-Model is corroborated (see below chart of Close Match Experiments 1-12 performed by Henry Templeman, CLPE)



It is significant to mention that for experiments #1-3 (i.e. 3 ending ridges in a funnel) twelve (12) expert latent print examiners (i.e. 6 CLPEs and 6 non-CLPEs) were asked to estimate how many look-alike clusters in excellent agreement (i.e. within friction ridge elasticity thresholds) would be present in a 1000 clear flat fingerprints selected at random from ten-print files. The results were as follows:

6 CLPEs: 333, 200, 56, 500, 650, and 300 (average ≈ 340)

6 non-CLPEs: 70, 20, 100, 550, 150 and 700 (average ≈ 265)

Cumulative average ≈ 302

Next, a population group of 1000 clear flat fingerprints were selected at random from ten-print files and searched to find out how many look-alikes were present. This was done for each of the 3 clusters of ending ridges in a funnel. The number of look-alikes observed for each experiment was counted. The results were as follows:

The number of look-alikes (close matches) found was 39, 30 and 33. The average number of look-alikes present was 34.

Next, the T-Model Fingerprint Calculator was used to estimate the number of look-alikes present in 1000 fingerprints. The result was 40.

Base on data from these experiments the following conclusions can be made:

- *There is solid basis to set the standard conservative (lower bound) discriminating value for 1 ending ridge unit in a funnel at approximately 10 (i.e. a match probability of 1/10).*

- *The product rule can be used to estimate the total discriminating value, or match probability, for clusters of ending ridge units in a funnel.*

- *The T-Model Fingerprint Calculator is the roughly 8 times more accurate than expert latent print examiners at estimating numbers of fingerprint look-alikes (specifically for clusters of ending ridges in a funnel) for a given flat fingerprint population group.*

- *Based on data gathered as a result of the experiment the T-Model is a reliable tool to estimate conservative (upper bound) numbers of look-alikes clusters of ending ridges in funnel present in a given fingerprint population group.*

If similar experiments were to be performed independently by latent print examiners that yielded similar results, then the T-Model would be corroborated and the data from the experiments could be used to support that corroboration, if necessary in court.

Question: Can you provide examples of how to determine values for fingerprint ridges?

Answer: See the T-Model workbook at www.facts.mynetworksolutions.com.

Question: Are all the values for ridge feature types corroborated by data gathered as a result of close match fingerprint experiments?

Answer: Yes.

Question: Are all the values for ridge feature positions corroborated by data gathered as a result of close match fingerprint experiments?

Answer: The values for ridge features with intervening ridge counts of 0-5 to the nearest neighbor have been corroborated by close match experiments. Based on the data gathered as a result of these experiments, the following mathematical symmetry between intervening ridge counts and discriminating values was observed:

$$V = Vp\ (2.5)^{(n-2)}$$

Where,

V = Value for Ridge Feature Position

Vp = Value for the previous ridge feature position

n = Number of intervening ridges to the nearest Level II neighbor for the previous ridge feature position

See below calculations to estimate ridge feature positions for "n" intervening ridges to nearest Level II neighbor:

0-2 Intervening Ridge to nearest Neighbor:	*1 x (2.5)^0=1*
3 Intervening Ridge to nearest Neighbor:	*4 x (2.5)^1=10*
4 Intervening Ridge to nearest Neighbor:	*10 x (2.5)^2=62.5*
5 Intervening Ridge to nearest Neighbor:	*62.5 x (2.5)^3=976*
6 Intervening Ridge to nearest Neighbor:	*976 x (2.5)^4=38,125*
7 Intervening Ridge to nearest Neighbor:	*38,125 x (2.5)^5=3,723,144*
8 Intervening Ridge to nearest Neighbor:	*3,723,144 x (2.5)^6=908,970,832*
9 Intervening Ridge to nearest Neighbor:	*908,970,832 x (2.5)^7=554,791,767,578*