**Precision: Level of Detail.**

Many models of memory propose that the brain stores precise or “verbatim” representations of an event that include the time and place it occurred, in parallel with more “gist-like” representations that primarily contain semantic (general meaning) information about the event.

*Verbatim*: “It was a hot day and I was in my white shorts and green t-shirt, standing at the front gate of the house, 10 ft from the front door, for 5 minutes while waiting for John to show up when a tall man, about 40 yrs old, with a blue suit on, walked up to me and pulled out a gun and told me to give him my phone.”

*Gist*: “I was robbed.”; “It was a summer day.”

Such models are generally referred to as **dual-process** **models** of memory, to highlight their contrast with **single-process** **models** that argue for a unitary process, such as memory strength, that governs the precision of the memory retrieval (i.e., stronger traces have more detail and weaker traces have less detail). It seems to me like computers primarily construe memory as a unitary process. Yet, the majority of contemporary memory researchers (including myself) favor some version of the dual-process model for humans (e.g., Yonelinas, Ranganath, Jacoby, Reyna & Brainerd) although there remain some strong proponents of the unitary theory (Squire, Wixted: http://www.ncbi.nlm.nih.gov/pubmed/20565205). Both “camps” often use **ROC (receiver operating characteristics)** to model memory and make their arguments. <http://en.wikipedia.org/wiki/Receiver_operating_characteristic>. I can elaborate more on this if you find this useful.

Some dual-process models, such as fuzzy-trace theory (FFT), have been used more broadly and have been applied to reasoning and decision making, as well as basic perceptual (vision) processing.

* Reyna, V.F.; Brainerd, C.J. (1995). "Fuzzy-trace theory: An interim synthesis". *Learning and Individual Differences* **7**: 1–75. [doi](http://en.wikipedia.org/wiki/Digital_object_identifier):[10.1016/1041-6080(95)90031-4](http://dx.doi.org/10.1016%2F1041-6080%2895%2990031-4)

Two additional points regarding what Scott wrote:

1. *“As more information is collected, a human is able to provide more detail” because “they can contextualize new information with previous knowledge and draw conclusions, effectively adding more information.”*
   1. In some cases this may be true. When incoming information can be associated with previously stored information in long-term memory it is more rapidly encoded, and more easily “elaborated,” creating a stronger, more durable memory. Humans may also be able to use existing knowledge to **strategically organize** incoming information so that memory buffers are used more efficiently.
   2. In some cases this may not be true. There are relatively low limits to how much information humans can keep in active memory (working memory) and as more information enters **working memory**, information that is not being actively maintained will passively decay, suffer from active interference from new representations and otherwise suffer. A computer can keep open many more files than my working memory can keep actively in mind.
   3. The **serial position effect** is another example of how information integrity is not always cumulative in a linear manner. When information is presented serially to a human, the initial and final items in the list will be better remembered than the middle items. The initial items get rehearsed and processed more, without the damaging effects of interference/confusion from previous items, whereas the last items can be read out quickly before they decay and also don’t suffer from interference from subsequent items (since they are last). The middle items are hit by interference from earlier and later items and rarely get the attention that the initial items get. (sorry for the wiki shortcut, but it’s easier than giving you 100 years of citations: http://en.wikipedia.org/wiki/Serial\_position\_effect
   4. So, it depends to some extent on whether the new information can be related to previous information without interfering with it. It also depends on the strength of the association between the new information and the previous information. Note that the **fan effect** shows that having more information linked to a particular concept actually slows down retrieval and can decrease accuracy. The fan effect has been modeled with ACT-R. http://ai.eecs.umich.edu/cogarch0/common/theory/fan.html
2. *“As time passes…humans will forget or merge details, whereas a computer memory is unchanging.”* 
   1. This seems to be more related to accuracy than precision per se, although it may relate to the **semanticization** of memory over time. Human memory theory makes a distinction between **episodic memory** – memories for autobiographical events, or at least events where their initial encoding/experience can be referenced to a specific time and place, and **semantic memory** – fact and event knowledge where retrieval is not accompanied by retrieval of the time and place of learning. Semantic memories are facts like “4 planes were involved in events of the terrorist attack on 9/11” whereas episodic memories would be your memory for where you were when you first heard about the events of 9/11. While you initially learned this “fact” in the context of a personal event, the “fact” was repeated over and over again in different contexts (i.e., the fact remains the same even if the context in which it is experienced changes), and this ultimately results in the loss of independent context details for each event in which it was experienced (i.e., the noise), while retaining the common information across these experiences (i.e., the signal). Moscovitch has some nice work on semanticization and the nuanced differences between general semantic knowledge and personal semantic knowledge.

**Accuracy: How close is what is stored to what was in the real world?**

For humans there are lots of ways accuracy can be lost. It can be lost at encoding, storage and/or retrieval.

*Encoding*:

* Humans do not always perceive information “correctly” or “objectively;” they do not simply “take in” information in an agnostic, purely “bottom-up” manner like a computer. Rather, their ability to attend to information in the environment is limited (they have poor completeness), and thus, **“top-down” expectations and biases** can influence what information they selectively attend to and how they interpret this information, which then influences what information is accessible to memory storage processes (my research is largely in this area).

*Storage*:

* Storage is subject to passive decay with time, active interference from new information (**proactive interference**) and active interference from old information (**retroactive interference**). Your graphs seem to primarily relate to this component of memory, but only consider the passive decay version, and also only the unitary memory model where all aspects of memory are remembered in a continuous strength fashion.

*Retrieval*:

* Obviously, if information is not encoded or stored properly, it will not be retrieved accurately, but even in the best of cases (where the memory was encoded as a close approximation of the sensory event and storage was not corrupted), retrieval can fail because the **retrieval cues** are poor.
* Human memory also has the oddness that it can get better over time. Witness the **“tip of the tongue” (TOT)** effect where full retrieval of information is initially blocked, although *enough* information is available so that the person “knows” they know the answer. Often TOTs resolve spontaneously (out of the blue) when the answer pops into mind. It has been argued that delays allowed dampening of activation of a stronger, but incorrect memory trace, allowing the correct, but lower strength memory trace to become accessible.

**Completeness: When have I retrieved enough?**

When I think about human memory in terms of “completeness,” the first thing that comes to mind is **metacognition**. Metacognitive **“judgments of learning” (JOLs)** have been studied as a measure of whether someone thinks they will later be able to recall something when they need to, and **metacognitive control** refers to decisions made on the basis of these types of judgments (i.e., deciding you need to spend more time learning something in order to be able to retrieve it later, or to have complete knowledge of something). Retrospective confidence judgments are also used at retrieval to decide whether the contents of your retrieval attempt are accurate and/or complete, and whether you should keep trying to get more information or you have exhausted the contents of your memory (i.e., the TOT phenomenon I mentioned above).

**Age: How long ago the information was generated**

You state that this metric is no different for human vs. computer memory. Certainly time passes for a computer the same as for a human in terms of distance between time of encoding and time of retrieval. However, in memory research there is a distinction between remote memories and recent long-term memories because they are stored somewhat differently (and are affected differently by brain damage). This is because the age of the memory influences how likely the memory will be semanticized (see discussion above about the effects of repeated exposure to an event and/or retrieval of an event and semanticization). It will also influence whether it has been consolidated (stabilized) or not.

**Timeliness: Delays between a request and delivery of information**

We can measure human timeliness in terms of reaction time (in a yes/no or forced-choice recognition memory test: http://www.ncbi.nlm.nih.gov/pubmed/19159148) or retrieval time (in a free recall test). There are **strong non-monotonic relationships between the memory strength (in unitary process models) and memory process (in dual process models).** Basically, in the unitary models, you are fast when memory strength is strong and when it is very weak (basically when you know you don’t know something) and slower when there is partial information or medium strength. In the dual process models, you are fast for items you recollect because you have a verbatim trace or strong familiarity/gist, then slower as familiarity gets weaker until finally it gets so weak that you think that the information has not been previously experienced before.