Current Biology
Magazine

Obituary

Ann Treisman (1935–2018)

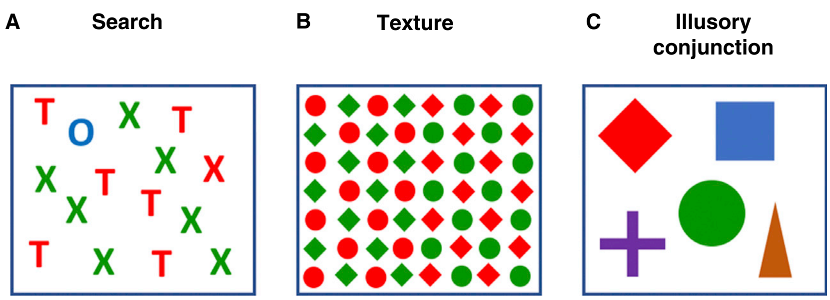
Jeremy M. Wolfe

Figure 1. Anne Treisman (1935–2018).
Photo courtesy of Deborah Treisman.

The worlds of psychology and cognitive science lost one of their most notable figures when Anne Treisman died on February 9, 2018, at the age of 82 at her home in New York City. In a slightly different universe, Treisman (Figure 1), who was one of the shaping forces in the modern study of attention, might have been a fine scholar of French Literature. Born on February 27, 1935, in Wakefield, Yorkshire, England, Anne Marie Taylor was interested in sciences in her high-school days, but, as she tells it in an autobiography that she wrote for the *Society for Neuroscience* [1], her father was panicked by the thought that she "would grow up without any culture", and so she specialized in French, Latin, and History. Her accomplishments in these fields took her to Cambridge (Newnham College) to read Modern Languages in the 1950s. On completing her degree, she was awarded a fellowship to allow her to work toward a doctorate in French Literature, but, in a move that would be difficult to negotiate in contemporary graduate-school admissions, she asked for and received permission to use the funds to support a second undergraduate degree — this time in Psychology. She was fortunate to have Richard Gregory as her supervisor. Through books like *Eye and Brain*, Gregory stimulated many people (including me) to take an interest in vision and in sensory information processing. Anne had the benefit of more direct influence, which may have been an early inspiration for her lifetime of clever perceptual experiments that pointed to important theoretical conclusions.

Her undergraduate work at Cambridge led to doctoral work at Oxford — not in vision, but in audition. Treisman became interested in the dichotic listening paradigm that Colin Cherry had pioneered. Cherry used headphones to present different streams of speech to each ear. Observers were asked to 'shadow' the input to one ear, quietly repeating it back. The important finding was that, even though you can't close an ear the way that you can close an eye, observers didn't know very much about what was presented to the unattended ear. Donald Broadbent had proposed that you could completely filter out the unattended channel but Treisman, along with classmate Neville Moray, was interested in the observation that some aspects of the unattended signal could be reported. Listeners could detect basic sensory properties (e.g. they would notice if the unattended speaker changed from male to female). They might also detect some aspects of meaning in the unattended stream: the classic example being one's own name (the famous 'cocktail party effect'). Treisman's theoretical contribution, 'Filter Attenuation Theory', argued that the unattended stimulus was damped down but not eliminated. This was an 'early selection' theory that held that attention acted on the initial stages of processing. The alternative 'late selection' approach of Deutsch and Deutsch [2] held that information was processed all the way through to full semantic processing and was then blocked only at a high cognitive stage or even at the response stage. Evidence accumulated for both positions. In Treisman's view, late selection findings are observed when the primary task (e.g. listening to the left ear) does not engage all of one's attentional capacity. In this case, excess capacity can lead to more attentional processing of the 'unattended' stimulus than the experimenter intended. A little bit of attention, leaking over from the attended ear, might be enough to register a salient stimulus, such as your name. When attention is fully engaged in the primary task, there is less leakage and early selection occurs. This insight was later developed into Load Theory by Nilli Lavie [3].

During this time, Anne was also building a family. She married Michel Treisman, a fellow graduate student at Oxford, in 1960. Four children followed — Jessica, Daniel, Stephen, and Deborah. She tended to downplay the difficulties she faced as a woman with serious commitments to both her family and to an academic career (she told good tales about putting baby Jessica in the soundproof booth in her lab "although I would never leave her there for long"). Looking back in 2014, she could write, "I was fortunate in being able to combine a large family



Current Biology

Figure 2. Examples of the empirical basis for Treisman's Feature Integration Theory.
(A) It is easier to find the blue O, defined by unique features, than the red X, defined by a conjunction of features. (B) It is not immediately obvious that the left and right sides of this texture are populated by different conjunctions of color and form. (C) After a brief glimpse, it is possible to be convinced that one has seen an illusory conjunction of the color of one shape with the form of another (e.g. a green square).

with an academic career, and I am now blessed with three successful children and four adorable granddaughters. Stephen, my Down syndrome child, is perhaps the happiest of them all."

Filter Attenuation Theory got Treisman into the textbooks, but her work in visual attention proved even more influential. In the 1970s, while Treisman was a lecturer at Oxford, first as a student and then as a faculty member, there was a growing body of work on separate analyzers or channels for different aspects of sensory processing. Properties like color and shape seemed to be handled by separate parts of the visual system. Within a property, there were a set of channels that could operate quite independently from one another. Your ability to detect a grating pattern of a high spatial frequency might be quite independent of your ability to detect a grating pattern of a low spatial frequency. This raised a problem. If the early stages of visual processing were taking the stimulus apart into its component features, how was the perceptually coherent world being put back together? We don't see isolated features. We see a visual world filled with unified objects that have color, shape, orientation, and so forth. The basic features are 'bound' to objects. How is that accomplished? If you had a red T and a green X, how did you know that the red belonged to the T and the green to the X? One possibility was that spatial colocation would do the trick. The red belonged to the T because the red and the T were in the same place. Treisman began to do some experiments that cast doubt on that simple explanation.

This important body of work began in Treisman's garden with her young children as the observers. Imagine a piece of paper, covered in red Ts and green Xs. In the midst of these items might be a red X or a blue O. She reports that the children had a much easier time finding the blue O. That should be introspectively obvious if you look at panel A of Figure 2. Treisman's contribution was to realize that this was theoretically important. There was something about looking for an instance of a unique feature — the blue color or the 'O' shape — that was fundamentally different from looking for a conjunction of two features, color and form. Treisman took these search experiments from the garden to the lab and systematically measured how long it took observers to find feature and conjunction targets as a function of how many total items were present in the display. In these reaction time studies, she found that it did not matter how many other items were present if observers were searching for a unique color or shape. The function relating the reaction times to the number of items (the 'set size') was essentially flat. The odd item 'popped out'. In contrast, in the search for conjunctions of, say, color and shape, reaction times increased linearly with set size. Moreover, they increased about twice as fast on target-absent trials, when observers had to confirm that there was no target. Such data were consistent with a process that examined each item in series, quitting when the target was found or when all items had been rejected. If there were N items in a target-present display, sometimes you would get lucky and the first attended item would be the target. Sometimes you would be very unlucky and you would need to search through all items before you stumbled on the target. On average, you would have to search through (N+1)/2 items. On the target-absent trials, in this account, you would need to examine all N items. As N increased, the increase in reaction times would be twice as great for target-absent trials as target present, thus the slopes of reaction time x set size functions would be twice as great for absent-trials as for present.

By the late 1970s, these experiments were taking place at the University of British Columbia. Her marriage to Michel Treisman ended in 1976. She married Daniel Kahneman in 1978, who survives her. At UBC, Treisman performed a slew of these search experiments. As an aside for those who only remember the computer era, it is worth noting that each stimulus for each trial in these experiments had to be hand drawn. Nor was there a computer recording and averaging the reaction times, let alone calculating the statistics. The results of this work formed the empirical basis for Feature Integration Theory. To briefly summarize the core ideas of Feature Integration Theory: there is a set of fundamental features that can be processed in parallel across the visual field. A unique color or shape, for example, can be detected instantly wherever it appears. After that, however, there is a bottleneck in processing. If you want to confirm the presence of a conjunction of basic features, it is necessary to direct attention to one item at a time, in series. Attention allows the binding of features into what Treisman would later call an 'object file'. Moreover, most acts of object recognition require that act of attentional binding. As a way to appreciate the counterintuitive fact that the features of unattended items may be in the same spatial location and yet may not be firmly bound to an object, look at panel B of Figure 2. At first glance, it appears to be a homogeneous texture of red and green circles and diamonds. Only with attentional scrutiny will you appreciate that the items on the left side differ from those on the right.

Another prediction of Feature Integration Theory is one of Treisman's favorite discoveries. Look very briefly at panel C of Figure 2, then look back here. Did you see a red circle? Did you see a blue plus? If you think you saw a blue plus, you experienced what Anne called an 'illusory conjunction'. Feature Integration Theory said that you needed attention to bind features like color and shape. If attention was attenuated, she reasoned, you might get failures of binding. These occur quite reliably in the lab (even if you did not happen to experience one just now) and they represent another example of Treisman's trademark ability to distill important science from simple experiments.

Feature Integration Theory has been widely influential: Treisman's seminal 1980 paper with Garry Gelade has been cited nearly 12,000 times (Google Scholar), and another half-dozen papers on the same general topic have been cited more than 1,000 times each. However, it was also not without critics. Indeed, I got into the field of attention because Whitman Richards marched down the hall at MIT and told me that I needed to "do something" about bits of Feature Integration Theory that he thought were incorrect. As part of my effort to do something, I tried to replicate Treisman's basic results. However, in my hands and in several other labs in the mid-1980s, conjunction searches produced reaction time x set size functions that were shallower than Treisman said that they should be. Of course, these and other attacks on Feature Integration Theory came to her attention. It is notable that, in the flood of memories that were shared after her death, virtually everyone remembered Anne as remarkably gracious and supportive in the face of scientific dispute. Nancy Kanwisher, who was Treisman's postdoc, said, "I remember us 'kids' in the lab worrying about the latest attack on feature integration theory," and Anne responding "with a mischievous grin and a sparkle in her eye, saying, 'Here we go again!'." My first paper on the topic was somewhat grandly titled *Guided Search: An alternative to the Feature Integration model for visual search*. I am glad to see that I thanked her in print for her help with the paper because she was remarkably generous with her time and thoughts. She and I spent a lot of time trying to figure out why my subjects were searching for conjunctions of color and orientation more efficiently than hers. In the end, the answer turned out to be a by-product of the march of technology. As noted, her stimuli were hand drawn with markers. I was using early computer graphics displays, and the higher contrast in my experiments was the critical factor.

The new findings required a modified theory. For instance, I argued that basic feature information 'guided' the deployment of the serial attention that I agreed was needed to bind features. If you were looking for a red vertical target among green vertical and red horizontal items, you might need attention to bind color to orientation, but 'preattentive' guidance could direct your attention to red rather than green items and toward vertical rather than horizontal items. Kind and generous though she was, Treisman wasn't about to simply yield the field to her critics. She modified Feature Integration Theory to accommodate the new data by incorporating some ideas quite like feature guidance. In later years, she could get rather annoyed when people continued to attack her 1980 model without paying attention to her subsequent modifications. That annoyance was never given a public airing. She was ready to engage in argument about her ideas but she was never argumentative. She defended her ideas incisively but without rancor. Charlie Gross captures her methodology when he describes co-teaching a graduate seminar with her: "The class soon understood that when Anne hesitantly said, 'I'm not sure I understand what you just said', they knew it meant 'what you just said was stupid and ignorant… but try again if you want.'"

Treisman and Kahneman moved to Berkeley in 1986 and to Princeton in 1993. In both schools, she raised tight-knit families of students who helped her continue to shape the study of attention. After Feature Integration Theory came important work on the nature of perceptual objects and on the state of vision away from the current focus of attention. We can't review all this work here. A good representative collection of Treisman's papers can be found in a book that Lynn Robertson and I edited in her honor in 2012 [4]. Suffice it to say that her body of work was acknowledged by President Barack Obama in 2013, when he awarded her the National Medal of Science "for a 50-year career of penetrating originality and depth that has led to the understanding of fundamental attentional limits in the human mind and brain" (Figure 3). Treisman leaves behind a scientific community transformed by her work and saddened by her death.

Figure 3. Anne Treisman receiving the 2013 National Medal of Science from President Barack Obama.
Photo courtesy of Deborah Treisman.

REFERENCES

1. Treisman, A. (2014). Anne Treisman. In The History of Neuroscience in Autobiography, L.R. Squire, (ed.) *8*, (Society for Neuroscience), pp. 510–552.
2. Deutsch, J.A., and Deutsch, D. (1963). Attention: Some theoretical considerations. Psychol. Rev. *70*, 80–90.
3. Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. J. Exp. Psychol. Hum. Percept. Perform. *21*, 451–468.
4. Wolfe, J.M., and Robertson, L.C. (2012). From Perception to Consciousness (Oxford: Oxford University Press).

Visual Attention Lab, Department of Surgery, Harvard Medical School, Brigham and Women's Hospital, 64 Sidney Street, Suite 170, Cambridge, MA 02139-4170, USA.
E-mail: jwolfe@bwh.harvard.edu; jeremywolfe0131@gmail.com