What links Albert Einstein, Keira Knightley, Leonardo da Vinci, Elon Musk, Muhammad Ali, Whoopi Goldberg, Winston Churchill, Thomas Edison, Richard Branson and countless other high achievers across many fields? The common strand is all of these individuals are dyslexic, in fact, some attribute their success to being dyslexic. Once traditionally seen as a disadvantage, dyslexia has in recent times come to be seen more accurately as a trade-off, which while presenting challenges in some areas, also offers significant advantages for certain skills, so much so that "Dyslexic thinking" has trended to become a recognised skill valuable to employers.

With growing awareness of neurodiversity generally, companies are having to adapt and ensure they offer inclusive workplaces. But what does that mean when applied to technologists?

Understanding Dyslexia

Let's start by breaking down what we mean by the term neurodiversity. This is an umbrella term that encompasses a range of specific learning differences. So what do we know about the learning differences of dyslexics?

Dyslexia is known to adversely affect phonological processing in 80-90% of dyslexic individuals. This is the system we use to process the composite parts of words. These building blocks of language form the foundation for the entire language structure which can then cause difficulty at all levels of the language. The phonological processing system plays an important role in working memory and executive function. Working memory is the kind of memory that helps us keep things in mind for conscious thought, but when working memory is limited the brain may fail to finish processing all it needs before it fades away, resulting in working memory overload.

However, this alone cannot account for all aspects of dyslexia such as problems with finger coordination for handwriting, eye movement control for reading or speech muscle control for speech articulation. The next key difference is procedural learning and procedural memory. Procedural learning is learning how to do something, and learning it to the point it's automatic so it no longer requires conscious effort. At least half of individuals with dyslexia have significant problems with procedural learning, and as a result, can be much slower to master skills that should become automatic through practice.

Dyslexic individuals with procedural challenges have difficulty learning rule-based skills, so must perform these skills using conscious attention and thought. The drawback of focused processing is that if too many parts of a complex task require attention then working memory can be overwhelmed. Procedural learning is essential for most basic skills, language is a prime example, but so are many academic skills. Psychologists have quantified the effects of this with the square root rule, that is if a task would take 4 hours to learn then it could take twice as long to learn if you are dyslexic, but if a task takes 100 hours for a non-dyslexic to learn then it could take 10 times as long to learn if you are dyslexic.

Next, there are also noticeable differences in the structure of the brains of dyslexics. In 1981 Dr Roger Sperry was awarded the Nobel Prize for his discovery that the two hemispheres of the brain process information very differently. Roughly speaking the left hemisphere specialises in fine-detail processing. The right hemisphere specialises in large-scale, big-picture features of objects or ideas. It is especially good at spotting connections that tie things together, seeing relationships between objects or ideas, determining the gist or purpose of an idea and identifying context and background relevant to a topic under inspection. Put succinctly, the left side sees the trees, while the right side sees the forest.

This is relevant because a growing body of evidence suggests dyslexics process far more information in their right hemisphere than non-dyslexics. Studies have used MRI scans to show which parts of the brain are active when reading. Reading is a task which is usually left hemisphere dominant as it requires detail and focus but dyslexics process far more information in the right hemisphere than non-dyslexics. In fact, reading does not start off as a left-hemisphere dominant skill, initially being processed by both sides of the brain, but through practice via procedural learning processing is shifted to the left hemisphere, but this transfer to the left side does not appear to occur in dyslexics. As a result errors in processing during reading occur more in dyslexics because they lack the fine grain detail-oriented processing the left hemisphere of the brain offers.

Finally, recent studies have discovered unusually large spacing between functional clusters of neurons in the cortex of dyslexic brains. The cortex is a thin sheet of cells that coats the surface of the brain. Neurons in the cortex then communicate with each other with a mix of chemical and electrical signals, which give rise to higher cognitive functions like conscious awareness, memory, attention, sensation and language. Throughout the population, this spacing between clusters fits the normal distribution in a population However dyslexics have a distinct bias toward the upper percentiles. This is important as researchers believe this allows dyslexics to make much wider connections in thought processes which gives rise to their tendency towards big-picture processing skills, and weakness in fine-detail processing. A consequence of these wider connections is dyslexics can end up processing more information, which exacerbates an already existing tendency towards an overload of working set memory. This may help to explain a common dyslexic trait, requiring more time in which to process information.

As a result of these differences, dyslexics get a trade-off in skill. Non-dyslexic brains excel in precision, accuracy, efficiency, speed, automaticity and detailed expertise. On the other hand, dyslexic brains excel at forming distant connections, getting the gist or essence of things, inferential reasoning and ambiguity detection, combining things in novel approaches leading to general inventiveness, and understanding associations and relationships. In short dyslexic brains function differently from non-dyslexic, not because they are defective, but because they are specialised for different strengths.

Dyslexic Characteristics

The Dyslexic Advantage examines in detail the strength and weaknesses encountered by dyslexics. These are categorised across material reasoning, interconnected reasoning, narrative reasoning and dynamic reasoning, the so-called MIND skills. A common theme we'll see across these is that dyslexic advantages arise as the result of variations in brain structure which optimises them for a particular task but comes with a "flip-side" trade-off.

Dyslexics have shown strength in 3D spatial reasoning skills where they outperform the general population. Two key components to strong material reasoning are the ability to store and accurately display spatial information in a mental image, and to be able to manipulate and modify these images. This gives rise to dyslexia's tendency to be linked to visual-based thinking styles. However, dyslexics underperform in 2D reasoning tasks, which feeds into some of the challenges encountered around the processing of symbols such as the written word.

Strength in interconnected reasoning creates the ability to spot connections between concepts, points of view, and different objects or events. That is associations like correlation, causation and effect. The ability to shift perspectives and adopt approaches borrowed from across many disciplines, and to unite information into a single global or big-picture view to get its gist and essential aspects. This allows for an advantage in interdisciplinary thinking which can aid a broad field view of a domain. But also comes at the cost of a top-down reasoning style which works best when a big-picture is in place. When starting out in a domain it can take longer for this style to build out this interconnected picture. As such dyslexics may be slower grasping a domain while parts of the picture are missing then suddenly switch to be able to make creative leaps and inferences once enough context is present. People with this thinking style are often bothered by gaps in their knowledge and may appear more easily distracted during tasks as they work to fill in the missing part of the picture. One strategy employed to aid this learning style is providing an overview (gist or context) in order to shortcut the context gathering that must happen to move from a bottom-down approach to a task to a top-down approach.

Another area of strength is that of narrative reasoning. This is tied closely to episodic memory, or factual memories in the form that simulates events, episodes or experiences. The majority of individuals with dyslexia exhibit a preference for episodic memory over other forms such as semantic memory. This presents itself as a tendency to store information as stories over other abstract forms. Dyslexics when asked to describe something are far more likely to use examples or analogies than abstract definitions (i.e. "its like when…" vs "it means that…").

This is closely related to the final trait of dynamic reasoning, which is being able to take in information and be able to accurately predict past and future occurrences. It is being able to notice patterns to imagine and correctly make predictions. This can be thought of as an episodic simulator, which is the ability to play out stories but is also closely related to how dyslexics reason about things, showing bias towards qualitative reasoning over abstract reasoning. In abstract reasoning, original observations are converted to generalisations, mathematical or symbolic representations. These abstract generalisations can be useful for reasoning about

typical cases but are less useful for thinking about unexpected, or unprecedented cases. However, this kind of episodic reasoning comes at a cost, speed and efficiency. A surprising pattern emerges amongst dyslexics strong in narrative and dynamic reasoning, is the process of working out a solution often worked backwards. That after a slow start reflecting on a problem dyslexics could often make intuitive leaps to the solution, then worked back in leaps of understanding the step to a solution. This presents numerous problems for outside observers, on the face of it, the dyslexic thinker appeared to be not be doing anything (during the time in which their brain was forming connections and processing information) and then when the solution is reached before working out steps to the solution we have an approach directly in conflict with the teaching of education systems which favour small incremental steps towards a solution. Suffice it to say, this approach to thinking is natural to a dyslexic so imposing a forward iterative approach to thinking can negatively impact areas dyslexics are naturally strong in, for instance, creativity and intuition.

Dyslexic in technology

Software engineering may not initially appear a natural fit for dyslexics due to the importance of fine detail and processing semantics and the symbology of a programming language. However, it is an environment in which there is significant tooling which can be leveraged to automate away the burden of manually checking the details of the complex system. Compilers offer instant feedback on the syntax and semantics of the language. Through a rigorous combination of continuous integration systems, layered with test systems such as unit testing, regression testing, integration testing, mutation testing and fuzzing plus automated error detection tools such as sanitisers, memory leak checkers, code coverage, performance benchmarks, etc, then developers can create an environment in which errors can be minimised. Additionally code review processes allow responsibility for checking the fine detail of a set of changes across the development team.

In actuality, software engineering is one domain where the differences in strengths of dyslexics can offer particular advantages. Writing code is all about building abstract structures that represent complex systems. The ability to visualise large interconnected systems, and make inferences about the relationships of components has a direct application. However, the other side of this equation must be considered, which is that as more information is processed then task completion may require more time and may be tied to the tendency to lose focus or uncover more peripheral issues to the core task as the big picture mental model of a system is being assembled. However, complex-systems is an area in which dynamic reasoning can be particularly applicable. The ability to play out the flow of a program is an essential basis for debugging an application, here the programmer must simultaneously run a simulation of expected behaviour based on their mental model of the program to spot where the expected and actual behaviour of a program begins to diverge. Much of the job of an engineer is problem-solving,

Accommodating interview processes for dyslexics

We've covered some of the theories but what does this practically mean for dyslexic individuals wanting to work in technology, or organisations wishing to be supportive of dyslexic hires? One stumbling block for dyslexic technologists can be the coding test now a common part of many interview processes. These are tests that stress rote learning solutions to particular classes of problems. This puts emphasis on procedural learning which as previously discussed can put a dyslexic candidate at a significant disadvantage. Cracking the coding interview the premier resource for software developers preparing interviews contains hours of exercises to prepare for interviews. One Facebook engineer comments this should equate to around 75 hours of study. However, if we apply the square rule previously examined to understand the effects on procedural learning then we gain a clear picture of how dyslexics may be disadvantaged. Here we reach a number of 650 hours, or over 3 months of continuous study to prepare for interviews. While anecdotal in nature it does hint at an industry issue which urgently requires further discussion.

One reasonable adjustment that is made in education systems across the world is the adjustment of time scales, where an additional 25% of the time is provided. However, this still aims to fit dyslexic thinkers conveniently into a world of non-dyslexics and in doing so risk stifling some of the talents hirings dyslexic candidates may offer such as creativity or big-picture thinking. More suitable is a task that aims to mitigate the issue around time requirements, by providing a flexible schedule in which to complete a challenge or task in their own time. Should the ability to program a task in under an hour really be critical to a job, then choosing a task with which the candidate is already familiar and leverages already existing skills, can alleviate challenges around procedural learning.

For companies wanting to support dyslexic workers then the government offers the access to work scheme. This can provide additional support, training, and funding for tools which can improve workflow for the dyslexic mindset. Additionally, companies might think about how to encompass aspects into candidates' roles which enable them to leverage their strengths. This should normally start with a conversation with that person but may also be an area in which coaching (as provided by access to work) can help an individual to tap into their strengths.

Conclusions

There are many well-documented cases of the contributions and high achievement possible by dyslexics. Some of these achievements may not have been possible without the shift in thinking which allowed intuitive leaps of creativity to find innovative solutions to problems. Hiring from neurodiverse backgrounds presents an opportunity to tap indirectly into these different ways of thinking and in doing so build a team with a wider coverage of skill sets. One of the biggest challenges faced by neurodivergent candidates is the tendency for society's norms to be based on the thinking of non-neurodivergent patterns, this can present challenges in being afforded the opportunity to work in a way which is natural to them. Empathy is required to understand the

thinking of others, this starts with an honest conversation and an openness to accept their norms non-judgmentally so as to build a clear picture of how their different perspectives process the world in a very different way. This requires not only communication but also introspection among all members of a team to understand each other's strengths but doing so presents an opportunity to strengthen collaboration within a team.