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Empathizing and systemizing

in autism spectrum conditions

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Autism Spectrum Conditions: Low, medium, and high functioning subgroups

Autism is diagnosed when a child or adult has abnormalities in a 'triad' of behavioural domains: social development, communication, and repetitive behaviour/obsessive interests (APA, 1994; ICD-10, 1994). In the 1960's and 70's, many of the children with autism who were studied by cognitive developmentalists also had comorbid learning difficulties (i.e. below average intelligence) and language delay (Frith, 1970; Hermelin & O'Connor, 1970; Wing, 1976). An average IQ of 60 was not uncommon in samples studied during that period. In the 1980's, cognitive developmentalists began to focus on what was then called 'high-functioning autism' (Baron-Cohen, Leslie, & Frith, 1985, 1986). In reality such children might be better described as 'medium-functioning', as although they had IQ's within the average range, this simply meant their IQ fell within 2 standard deviations (sd's) from the population mean of 100. Since 1 sd is 15 points, this means that anyone with an IQ above 70 would still have been included in this band. An IQ of 71 is by statistical definition average, but is hardly high-functioning.

By the 1990s, interest had shifted to studying the truly high-functioning strata of the autistic spectrum: those whose IQ's were close to 100 or above. This would have included those with 'superior IQ', i.e. those whose IQ was higher than 2 sd's above the population mean (Baron-Cohen, Joliffe, Mortimore, & Robertson, 1997; Frith, 1991; Jolliffe & Baron-Cohen, 1997; Klin, Volkmar, Sparrow, Cicchetti, & Rourke, 1995; Szatmari, Tuff, Finlayson, & Bartolucci, 1990). Since we know that IQ is a strong predictor of outcome in autism (Rutter, 1978), it is important to take IQ into account.

Asperger Syndrome (AS) was first described by Asperger (Asperger, 1944). The descriptions of the children he documented overlapped considerably with the accounts of childhood autism (Kanner, 1943). Little was published on AS in English until relatively recently (Frith, 1991; Wing, 1981). Current diagnostic practice recognises people with AS as meeting the same criteria as for high-functioning autism (HFA), but with no history of language delay, and with no cognitive delay. In concrete terms, this mean that as a toddler, the individual was speaking on time (i.e. single words by age 2, and/or phrase speech by 3 years old) and has had a mental age in line with their chronological age (i.e., an IQ in the normal range). Although some studies have claimed a distinction between AS and HFA (Klin et al., 1995), the majority of studies have not demonstrated many, if any, significant differences between these.

This background into autism and intelligence is important, because it reveals that over the last 40 years there has been a major shift in research strategy. When studying the cognitive development of autism, one strategy (and one we will focus on here) is to identify the deficits or talents that are present in all 3 sub-groups, (low-, medium-, and high-functioning). In this way, we can characterise necessary, core characteristics of people on the autism spectrum and test if a cognitive theory can account for such core features. At the same time, we can clarify those associated characteristics that may occur more frequently than chance, but may not lie in this core. The list of *associated* (but not universal) characteristics is very long, and includes the following: language delay, learning disability, self-injury, clumsiness, ADHD, epilepsy, gastro-intestinal inflammation, hyperlexia, and non-right-handedness. We suggest that the *core characteristics* comprise two triads of characteristics:

Triad A: social difficulties, communication difficulties, and difficulties in imagining other people's minds.

Triad B: strong, narrow obsessional interests, repetitive behaviour, and 'islets of ability'.

This new view builds on the concept of the triad, but extends this into *two* triads (Wing & Gould, 1979). In the next section, we look at some different cognitive theories, to see how well they can account for these two triads of characteristics.

a. The Mindblindness/ Empathizing theory

The mindblindness theory of autism (Baron-Cohen, 1995), and its extension into empathizing theory (Baron-Cohen, 2002) proposes that in autism spectrum conditions there are deficits in the normal process of empathizing, relative to mental age. These deficits can occur by degrees. The term 'empathizing' encompasses the following earlier terms: 'theory of mind', 'mind-reading', and taking the 'intentional stance' (Dennett, 1987).

Empathizing involves two major elements: (a) the ability to attribute mental states to oneself and others, as a natural way to understand agents (Baron-Cohen, 1994a; Leslie, 1995; Premack, 1990); (b) having an emotional reaction that is appropriate to the other person's mental state. In this sense, it includes what is normally meant by the term 'theory of mind' (the attributional component) but it goes beyond this, to also include having some affective reaction (such as sympathy).

The first of these, the mental state attribution component, has been widely discussed in terms of being an evolved ability, given that in the universe can be broadly divided into two kinds of entities: those that possess intentionality and those that do not (Brentano, 1970). The mental state attribution component is effectively judging if this is the sort of entity that might possess intentionality. Intentionality is defined as the capacity of something to refer or point to things other than itself. A rock cannot point to anything. It just is. In contrast, a mouse can 'look' at a piece of cheese, it can 'want' the piece of cheese, and it can 'think' that this is a piece of cheese, etc. Essentially, agents have intentionality, whereas non-agents do not.

This means that when we observe agents and non-agents move, we construe their motion as having different causes (Csibra, Gergely, Biro, Koos, & Brockbanck, 1999; Gelman & Hirschfield, 1994). Agents can move by self-propulsion, which we naturally interpret as driven by their goals and desires, whilst non-agents can reliably be expected not to move unless acted upon by another object (e.g., following a collision). Note that mental state attribution is quite broad, since it includes not just attribution of beliefs, desires, intentions, thoughts and knowledge, but also perceptual or attentional states, and all of the emotions (Baron-Cohen, Wheelwright, Hill, & Golan, submitted; Griffin & Baron-Cohen, 2002).

The second of these, the affective reaction component, is closer to what we ordinarily refer to with the English word ‘empathy’. Thus, we not only attribute a mental state to the agent in front of us (e.g., the man ‘thinks’ the cake is made of soft, creamy chocolate’), but we also anticipate his or her emotional state (the man will be disappointed when he bites into it and discovers it is hard and stale), and we react to his or her emotional state with an appropriate emotion ourselves (we feel sorry for him). Empathizing thus essentially allows us to make sense of the behaviour of another agent we are observing, predict what they might do next, and how they might feel. And it allows us to feel connected to another agent’s experience, and respond appropriately to them.

The normal development of empathizing

Empathizing develops from human infancy (Johnson, 2000). In the infancy period, it includes

- being able to judge if something is an agent or not (Premack, 1990);
- being able to judge if another agent is looking at you or not (Baron-Cohen, 1994b);
- being able to judge if an agent is expressing a basic emotion (Ekman, 1992), and if so, what type.

- engaging in shared attention, for example by following gaze or pointing gestures (Mundy & Crowson, 1997; Scaife & Bruner, 1975; Tomasello, 1988);
- showing concern or basic empathy at another's distress, or responding appropriately to another's basic emotional state (Yirmiya, Sigman, Kasari, & Mundy, 1992);
- being able to judge an agent's goal or basic intention (Premack, 1990).

Empathizing can be identified and studied from at least 12 months of age (Baron-Cohen, 1994a; Premack, 1990). Thus, infants show dishabituation to actions of 'agents' who appear to violate goal-directedness (Gergely, Nadasdy, Gergely, & Biro, 1995; Rochat, Morgan, & Carpenter, 1997). They also expect agents to 'emote' (express emotion), and expect this to be consistent across modalities (between face and voice) (Walker, 1982). They are also highly sensitive to where another person is looking, and by 14 months will strive to establish joint attention (Butterworth, 1991; Hood, Willen, & Driver, 1997; Scaife & Bruner, 1975). By 14 months they also start to produce and understand pretence (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Leslie, 1987). By 18 months they begin to show concern at the distress of others (Yirmiya et al., 1992). By 2 years old they begin to use mental state words in their speech (Wellman & Bartsch, 1988).

Empathizing of course develops beyond early childhood, and continues to develop throughout the lifespan. These later developments include:

- attribution of the range of mental states to oneself and others, including pretence, deception, belief (Leslie & Keeble, 1987).

- recognizing and responding appropriately to complex emotions, not just basic ones (Harris, Johnson, Hutton, Andrews, & Cooke, 1989).
- linking mental states to action, including language, and therefore understanding and producing pragmatically appropriate language (Tager-Flusberg, 1993)
- making sense of others' behaviour, and predicting it, and even manipulating it (Whiten, 1991).
- judging what is appropriate in different social contexts, based on what others will think of our own behaviour.
- communicating an empathic understanding of another mind.

Thus, by 3 years old, children can understand relationships between mental states such as seeing leads to knowing (Pratt & Bryant, 1990). By 4 years old they can understand that people can hold false beliefs (Wimmer & Perner, 1983). By 5-6 years old they can understand that people can hold beliefs about beliefs (Perner & Wimmer, 1985). By 7 years old they begin to understand what ***not*** to say, to avoid offending others (Baron-Cohen, O'Riordan, Jones, Stone, & Plaisted, 1999). With age, mental state attribution becomes increasingly more complex (Baron-Cohen et al., 1997; Happe, 1993). The little cross-cultural evidence that exists suggests a similar picture in very different cultures (Avis & Harris, 1991).

These developmental data have been interpreted in terms of an innate module being part of the infant cognitive architecture. This has been dubbed a theory of mind mechanism (ToMM) (Leslie, 1995). But as we have suggested, empathizing also encompasses the skills that are needed for normal reciprocal social relationships (including intimate ones) and in sensitive communication. Empathizing is a narrowly defined domain, namely, ***understanding and responding to people's minds***. Deficits in empathizing are referred to as degrees of mindblindness.

Empathizing in autism spectrum conditions

Since the first test of mindblindness in children with autism (Baron-Cohen et al., 1985), there have been more than 30 experimental tests. The vast majority of these have revealed profound impairments in the development of their empathizing ability. These are reviewed elsewhere (Baron-Cohen, 1995; Baron-Cohen, Tager-Flusberg, & Cohen, 1993) but include deficits in the following:

- joint attention (Baron-Cohen, 1989c);
- use of mental state terms in language (Tager-Flusberg, 1993);
- production and comprehension of pretence (Baron-Cohen, 1987; Wing & Gould, 1979);
- understanding that "seeing-leads-to-knowing" (Baron-Cohen & Goodhart, 1994; Leslie & Frith, 1988);
- distinguishing mental from physical entities (Baron-Cohen, 1989a; Ozonoff, Pennington, & Rogers, 1990);
- making the appearance-reality distinction (Baron-Cohen, 1989a);
- understanding false belief (Baron-Cohen et al., 1985);

- understanding beliefs about beliefs (Baron-Cohen, 1989b);
- understanding complex emotions (Baron-Cohen, 1991);
- showing concern at another's pain (Yirmiya et al., 1992).

Some children and adults with AS only show their empathizing deficits on age-appropriate adult tests (Baron-Cohen et al., 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Baron-Cohen, Wheelwright, & Jolliffe, 1997), or on age-appropriate screening instruments such as the Empathy Quotient (EQ) (Baron-Cohen, Richler, Bisarya, Gurunathan, & Wheelwright, 2003; Baron-Cohen & Wheelwright, in press-a) or the Friendship and Relationship Quotient (FQ) (Baron-Cohen & Wheelwright, in press-b).

b. The Empathizing-Systemizing theory

A deficit in empathizing might account for Triad A: the social and communication abnormalities that are diagnostic of autism, and it could even account for difficulties in *imagining* other people's mental states. However, such a deficit has little if anything to contribute to our understanding of Triad B: repetitive behaviour, obsessions, and the islets of ability. For this reason, our view of autism is now broader, and suggests that alongside empathizing deficits, a different process is *intact or even superior*. This process is what we call *systemizing* (Baron-Cohen et al., 2003).

What is systemizing?

Whereas we think of empathizing as the drive to identify and to respond affectively to agents' mental states, in order to understand and predict the behaviour of that agent, we think of systemizing as the drive to analyse and build systems, in order to understand and predict the behaviour of non-agentive events. Systems are all around us in our environment, and fall into at least 6 classes: *technical* systems (such as machines and tools); *natural* systems (such as biological and geographical phenomena); *abstract* systems (such as mathematics or computer programs); *social* systems (such as a business, or a football league); *motoric* systems (such as a juggling technique, or a Frisbee throw); and *organisable* systems (such as a collection, a taxonomy, or a list).

The way we make sense of any of these systems is not in terms of mental states, but rather in terms of underlying rules and regularities. Systemizing involves an initial analysis of the system down to its lowest level of detail in order to identify potentially relevant *parameters* that may play a causal role in the behaviour of the system. These parameters are then systematically observed or manipulated one by one, and their effects on the whole system are noted. To put it succinctly, systemizing entails an analysis of input-operation-output relationships. Once the operations on inputs are identified and checked, the output of the system becomes totally predictable.

Systemizing in autism spectrum conditions

Are people with autism intact or even superior at systemizing? We know from clinical descriptions of children with autism that they are typically fascinated by machines (the paragon of non-intentional systems). Parents' accounts (Hart, 1989; Lovell, 1978; Park, 1967) are a rich source of such descriptions. Typical examples include extreme fascinations with electricity pylons, burglar alarms, vacuum cleaners, washing machines, video players, trains, planes, and clocks. Sometimes the machine that is the object of the child's obsession is quite simple (e.g., the workings of drainpipes, or the design of windows, etc.). Our survey of obsessions in children with autism substantiated this clinical observation that their preoccupations tend to cluster in the area of systems (Baron-Cohen & Wheelwright, 1999).

The child with an autism spectrum condition who has enough language, such as is seen in children with AS, may be described as holding forth, like a "little professor", on their favourite subject or area of expertise, often failing to detect that their listener may have long since become bored of hearing more on the subject. The apparently precocious systematic understanding, whilst being relatively oblivious to their listener's level of interest, suggests that their systemizing might be outstripping their empathizing skills in development. The anecdotal evidence includes not just an obsession with machines (technical systems), but with other kinds of systems. Examples of their interest in natural systems include obsessions with the weather (meteorology), the formation of mountains (geography), motion of the planets (astronomy), and the classification of lizards (taxonomy).

Experimental studies converge on the same conclusion: children with autism not only have an intact intuitive physics, they have accelerated or superior development in this domain (relative to their empathizing and relative to their mental age, both verbal and non-verbal). For example, using a picture sequencing paradigm, children with autism performed significantly better than mental-age matched controls in sequencing physical-causal stories (Baron-Cohen et al., 1986). Two studies found children with autism showed superior understanding of a camera (Leekam & Perner, 1991; Leslie & Thaiss, 1992). In two direct test of intuitive physics in children and adults with AS (Baron-Cohen, Wheelwright, Hill et al., 2001; Lawson, Baron-Cohen, & Wheelwright, in press) people with AS were found to be functioning at a normal or even superior level, relative to controls. Finally, using the Systemizing Quotient (SQ), it was found that adults with AS scored higher than controls (Baron-Cohen et al., 2003).

Family studies of empathizing and systemizing

Family studies add to this picture. Parents of children with Asperger Syndrome (AS) also show mild but significant deficits on an adult mindreading task (the adult version of the 'Reading the Mind in the Eyes' task). This mirrors the deficit in empathizing seen in patients with autism or AS (Baron-Cohen & Hammer, 1997b; Baron-Cohen, Wheelwright, Hill et al., 2001). This familial resemblance at the cognitive level is assumed to reflect genetic factors, since autism and AS appear to have a strong heritable component (Bailey et al., 1995; Bolton et al., 1994; Folstein & Rutter, 1977; Le Couteur et al., 1996).

One should also expect that parents of children with autism or AS to be over-represented in occupations in which possession of superior systemizing is an advantage, whilst a deficit in empathizing would not necessarily be a disadvantage. A clear occupation for such a cognitive profile is engineering. A study of 1000 families found that fathers and grandfathers (patri- and matrilineal) of children with autism or AS were more than twice as likely to work in the field of engineering, compared to fathers and grandfathers of children with other disabilities (Baron-Cohen, Wheelwright, Stott, Bolton, & Goodyer, 1997). Indeed, 28.4% of children with autism or AS had at least one relative (father and/or grandfather) who was an engineer. Related evidence comes from a survey of students at Cambridge University, studying either sciences (physics, engineering, or maths) or humanities (English or French literature). When asked about family history of a range of psychiatric conditions (schizophrenia, anorexia, autism, Down's Syndrome, or manic depression), the students in the science group showed a six-fold increase in the rate of autism in their families, and this was specific to autism (Baron-Cohen et al., 1998).

Plotting empathizing and systemizing

If empathizing and systemizing are independent dimensions, it is possible to plot on orthogonal axes possible scores from possible tests assessing these two abilities. Figure 1 provides a visual representation of this model of the relationship between empathizing and systemizing. It suggests appropriate labels for different possible patterns of scores. The axes show number of standard deviations from the mean. The scale of the diagram is less important than the principle underlying it.

Insert Figure 1 here

We have used the terms *Brain Type B (Balanced), Brain Type E (Empathizing), Brain Type S (Systemizing),* to describe the 3 basic Brain Types that are generated from this model. These all fall within 2 standard deviations from the mean on both dimensions. We have also shown on the graph the *extremes* of Brain Types S and E. The terms describe the discrepancy between the empathizing score and the systemizing score. In the Balanced Brain, there is no difference between scores (i.e. E=S). In Brain Type E, empathizing is one or two standard deviations higher than systemizing (i.e. E>S). In the Extreme Brain Type E, this discrepancy is greater than two standard deviations (i.e. E>>S). In Brain Type S, systemizing is one or two standard deviations higher than empathizing (i.e. S>E). For the Extreme Brain Type S, this discrepancy is greater than two standard deviations (i.e. S>>E).

It is worth underlining the fact that the key point is the discrepancy between the scores rather than the absolute scores themselves. For example, someone could score two standard deviations above the mean on empathizing (a very high score) but if they scored three standard deviations above the mean on systemizing, they would be described as having Brain Type S. Thus, the key issue is possible asymmetries of ability.

Evidence from sex difference research (Kimura, 1992) suggests that Brain Type S is more commonly found in males, whilst Brain Type E is more frequent in females. For this reason we can also use the terminology ***Female Brain*** and ***Male Brain types*** as synonyms for Brain Types E and S, respectively. One result which is consistent with this idea is that human neonates, one day old, show a sex difference: female babies look longer at a human face than a mechanical mobile, whilst male babies show the opposite pattern of preferences (Connellan, Baron-Cohen, Wheelwright, Ba'tki, & Ahluwalia, 2001).

c. The Extreme Male Brain (EMB) theory

Autism has been described as the extreme of the male brain (Asperger, 1944; Baron-Cohen, 2002; Baron-Cohen & Hammer, 1997a). There are a number of pieces of evidence that are consistent with the EMB theory of autism. First, regarding empathizing measures, females score higher than males on tests of understanding *faux pas*, and people with AS score even lower than unaffected boys (Baron-Cohen, Wheelwright, Stone, & Rutherford, 1999; Lawson et al., in press). Second, girls make more eye-contact than boys (Lutchmaya, Baron-Cohen, & Raggett, 2002) and children with autism make even less eye contact than unaffected boys (Swettenham et al., 1998). Thirdly, girls tend to pass false belief tests slightly earlier than boys (Happe, 1995), and children with autism are even later to pass false belief tests. Finally, women score slightly higher than men on the test of ‘Reading the Mind in the Eyes’, and adults with AS or high functioning autism score even lower than unaffected men (Baron-Cohen et al., 1997). There are also established sex differences in systemizing, males tending to score higher on tests of folk physics, map-use, and mental rotation, for example (Kimura, 1999), and people with autism being at least intact if not superior on these tasks (Baron-Cohen et al., 2003; Baron-Cohen, Wheelwright, Scahill, Lawson, & Spong, 2001; Lawson et al., in press).

This model of the independence of empathizing and systemizing also predicts the existence of very high functioning individuals with AS, who may be extreme high achievers in domains such as mathematics and physics - equivalent to Nobel Prize winners even - but who have deficits in empathizing. Some case studies are beginning to identify such very high-functioning individuals (Baron-Cohen, Wheelwright et al., 1999).

d. Other models of cognitive development in autism

In this final section, we briefly summarise some other cognitive developmental theories of autism, since these are important alternatives against which to consider the empathizing-systemizing theory.

Executive function theory

People with autism spectrum conditions show “repetitive behaviour”, a strong desire for routines, and a “need for sameness”. To date, the only cognitive account to attempt to explain this aspect of the syndrome is the executive dysfunction theory (Ozonoff, Rogers, Farnham, & Pennington, 1994; Pennington et al., 1997; Russell, 1997a). This paints an essentially negative view of this behaviour, assuming that it is a form of ‘frontal lobe’ perseveration or inability to shift attention.

We recognize that some forms of repetitive behaviour in autism, such as ‘stereotypies’ (e.g., twiddling the fingers rapidly in peripheral vision) are likely to be due to executive deficits. Moreover, we recognize that as one tests people with autism who have additional learning disabilities, executive deficits are more likely to be found (Russell, 1997b). But the fact that it is possible for people with AS to exist who have no demonstrable executive dysfunction whilst still have deficits in empathizing and talents in systemizing suggests that executive dysfunction cannot be a core feature of autism spectrum conditions.

The executive account has also traditionally ignored the *content* of “repetitive behaviour”. The empathizing-systemizing theory in contrast draws attention to the fact that much repetitive behaviour involves the child’s ‘obsessional’ or strong interests with mechanical systems (such as light switches or water faucets) or other systems that can be understood in terms of rules and regularities. Rather than these behaviours being a sign of executive dysfunction, these may reflect the child’s intact or even superior development of their systemizing. The child’s obsession with machines and systems, and what is often described as their “need for sameness” in attempting to hold the environment constant, might be signs of the child as a superior systemizer. The child might be conducting mini-experiments in his or her surroundings, in an attempt to identify physical-causal or other systematic principles underlying events.

One possibility then is that the strong drive to systemize seen in autism spectrum conditions may underlie the ‘Triad B’ features (repetitive behaviour, ‘obsessional’ or narrow interests, and the islets of ability).

Central coherence (CC) theory

It could be argued that good systemizing skills are simply an expression of an anomaly previously documented, namely ‘weak’ central coherence (Frith, 1989; Happe, 1996). Weak central coherence refers to the individual’s preference for local detail over global processing. This has been demonstrated in terms of an autistic superiority on the Embedded Figures Task (EFT) and the Block Design Subtest (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983, 1993). It has also been demonstrated in terms of an autistic deficit in integrating fragments of objects and integrating sentences within a paragraph (Joliffe & Baron-Cohen, 2001; Jolliffe & Baron-Cohen, 2001). The faster and more accurate performance on the EFT and Block Design Test have been interpreted as evidence of good segmentation skills, and superior attention to detail. The latter has also been demonstrated on visual search tasks (Plaisted, O'Riordan, & Baron-Cohen, 1998a, 1998b).

Our view of systemizing certainly embraces aspects of the central coherence theory. For example, systemizing requires as a first stage an excellent attention to detail, identifying parameters that may then be tested for their role in the behaviour of the system under examination. So, both the E-S theory and the CC theory predict excellent attention to detail. However, the E-S and CC theories also make opposite predictions when it comes to an individual with autism being able to understand a whole system. The E-S theory predicts that a person with autism, faced with a new system to learn, will learn it faster than someone without autism, so long as there are underlying rules and regularities that can be discovered. Moreover, they will readily grasp that a change of one parameter in one part of the system may have distant effects on another part of the system. Thus, if the task is a constructional one (building a model plane, for example), they will be able to grasp that changing the thickness of the wings may cause the plane to land at a steeper angle. This kind of reasoning clearly involves good central coherence of the system. What is being understood is the ***relationship*** between one parameter and one distal outcome. In contrast, the CC theory should predict that they should fail to understand whole (global) systems or the relationships between parts of a system. This has not yet been tested.

Summary

This chapter has reviewed both the early mindblindness theory of autism, and the more recent extensions of these: the empathizing-systemizing theory, and the extreme male brain theory, of autism. The first of these extensions addresses a problem that the early theory had, namely, needing to also account for the obsessional features of autism. The second of these may help explain the marked sex ratio in autism and throw light on the biological basis of autism (Lutchmaya & Baron-Cohen, 2002). Both of these extensions lead to new predictions when contrasted with other cognitive developmental theories of this condition, and illustrate some of the progress that is being made in this part of the field of developmental psychopathology.

Figure 1: Explaining the core characteristics of autism spectrum conditions in terms of empathizing and systemizing

[separate powerpoint slide attached]

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