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To cite this article: David Pinzur & Tom Duterme (13 Jan 2025): Market devices and infrastructures: how they differ and why it matters, Journal of Cultural Economy, DOI: [10.1080/17530350.2024.2409798](https://doi.org/10.1080/17530350.2024.2409798)

To link to this article: <https://doi.org/10.1080/17530350.2024.2409798>



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Published online: 13 Jan 2025.



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Market devices and infrastructures: how they differ and why it matters

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ABSTRACT

This article seeks to clarify the relationship between market studies research associated with the notions of ‘market devices’ and ‘market infrastructures.’ The relation between these terms has remained hazy in prior work, impeding their conjunction in analyses of markets. We treat devices and infrastructures as deeply entwined components of market *agencements*, which interact in the everyday performance of markets. However, these components remain distinguishable on the basis of two dimensions: the extension and unavoidability of their networks. These dimensions both facilitate empirical research on the interaction of devices and infrastructures and offer insight on the dynamics between them: the asymmetrical, limiting influence of infrastructure; the potential challenges posed by devices; the ever-present possibility of roles shifting over time. This conceptualization of how the terms differ then anchors our analysis of why the distinction matters. Infrastructures and devices make discrete contributions to the framing of the market (what we call ‘radical’ and ‘instrumental’ framing), which empower actants via different mechanisms (e.g. the ‘discretionary’ power that accrues to key infrastructural actants). The article establishes a basis for an expansion of sociomaterial research on markets, providing both empirical strategies and theoretical questions for future work.

ARTICLE HISTORY

Received 22 September 2023

Accepted 2 September 2024

KEYWORDS

Infrastructure; device; market studies; framing; agencements; infrastructural power

Introduction

For at least the past 25 years, social scientists have attempted to understand markets as emerging from hybrid, sociomaterial processes. This research, inspired by the work of Michel Callon (1986, 1998), has mobilized concepts such as actor-networks, sociomaterial assemblages, and particularly market devices and *agencements*. Recently another term with roots in science and technology studies (Bowker and Star 2000; Star and Ruhleder 1996) has found favor in the study of markets: infrastructure.¹ Briefly, infrastructure refers to large-scale, backgrounded systems that accomplish basic tasks, invisibly setting the stage for everyday market behaviors such as calculation and exchange. Examples of market infrastructures from the literature include stock exchange order books (Pardo-Guerra 2019), clearing houses (Genito 2019), payment systems (Brandl and Dieterich 2023; Westermeier 2020), the SWIFT interbank communication network (Dörny, Robinson, and

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Derudder 2018), price and statistical networks (Pinzur 2021a), and blockchains (Çalışkan 2020). It thus expands sociomaterial analyses of markets to objects and concerns beyond the immediate environments of traders in the market. Excitement around the concept has led to a flowering of new work. The past five years have seen the publication of Juan Pablo Pardo-Guerra's (2019) book-length analysis of the infrastructures underlying electronic markets, as well as increasing references to infrastructure in this and similar journals, including a special issue of *Review of International Political Economy* (Bernards and Campbell-Verduyn 2019) that used infrastructure as a theoretical throughline for studying finance and technology. A massive *Cambridge Companion to Financial Infrastructure* is forthcoming.

The ambition of this paper is to clarify the relationship between this infrastructural turn and prior sociomaterial approaches to markets. In particular, we focus on two key concepts: market devices and infrastructures. The paper argues that the turn to infrastructure – as exciting and generative as it has been – must not come at the expense of an engagement with the older notion of market devices. In fact, it is only by approaching devices and infrastructures as co-contributors to the ongoing projects of framing the market, enabling calculation, and equipping action that their full value for sociomaterial market research becomes clear. Embracing the turn to infrastructure requires saving the device, not abandoning it.

Our argument unfolds in several steps. We begin by tracing the introduction of the device concept and the turn to infrastructure and discuss the underappreciated basis for a theoretical synthesis between these terms. We then argue that infrastructures and devices should be understood as distinct, but deeply entwined, components of the same market *agencements* – distributed, sociomaterial assemblages endowed with the capacity to act in the market (Çalışkan and Callon 2010). This draws the two concepts into a single theoretical framework, laying the ground for our analysis. Following this, we consider how to distinguish the terms within this shared framework. We proffer a two-dimensional distinction along which devices and infrastructures, as elements of *agencements*, can be empirically and conceptually identified: the extension and unavoidability of their networks. These dimensions facilitate the operationalization of these concepts in empirical settings and offer a robust theoretical base for future research.

The next two sections of the article explore why this proposed relation matters. We first highlight how the dimensions of extension and unavoidability make visible the interaction between and evolution of infrastructures and devices. These include the asymmetrical, limiting influence of infrastructure, the occasionally challenging application of devices, as well as the possibilities of infrastructuralization or de-infrastructuralization as networks change in their extension and optionality. Following that, we analyze the consequences of this interaction in terms of infrastructures' and devices' impact on and power within markets. We argue that infrastructures and devices make discrete contributions to the framing of the market (what we call 'radical' and 'instrumental' framing) and empower actants via different mechanisms (e.g. the 'discretionary' power that accrues to key infrastructural actants). We conclude by drawing out further theoretical implications of this analysis as well as practical suggestions for scholars taking a sociomaterial approach to markets.

The critique of devices and emergence of infrastructures

The sociomaterial turn of market studies

The introduction of perspectives from science studies to economic sociology has significantly altered how sociologists understand markets. First, economic actors and their 'environment' are no longer considered as distinct components contributing to outcomes in their own ways (i.e. agency and structure), but rather as elements of a single *agencement* – a distributed, hybrid, sociomaterial assemblage endowed with the capacity to act in the market. Second, market action is understood to be impacted not simply by familiar sociological factors (e.g. culture, law,

hierarchy, etc.) but also by the material components of the market, including bodies, machines, and calculative prostheses. Thirdly, markets are conceptualized not as an unproblematic and already constituted part of social reality, but as heterogeneous constructions – continually in the process of being made – whose contents are delineated by a temporary boundary. Within this new perspective, the goal of analysis is not applying extant sociological theories to markets, but rather tracing the process of marketization via the continual weaving together and formatting of individuals, organizations, texts, and physical objects (Çalışkan and Callon 2010; Callon 2021; Fourcade 2007).

This radically different approach to markets requires new concepts that can accommodate sociomaterial hybridity, networked forms, and ontological fluidity. The conceptual binomial of ‘market devices’ and ‘framing’ serves this purpose. Callon (1998) defines framing as the operation that temporarily stabilizes economic networks so as to allow calculation and exchange to occur: it is the process by which actors and objects – no longer ‘economic’ by nature – are rather *made* economic. Framing is accomplished not simply by cultural means, but through the intervention of ‘material and discursive assemblages,’ known as market devices (Muniesa, Millo, and Callon 2007, 2). These associate together components of a network, creating a distributed, heterogeneous market object or actor. The concepts of device and frame are thus mutually defining: the operation of framing is carried out by market devices; the solidification of a frame bolsters the utility of the device. For example, economic models act as devices (i.e. assemblages of heterogeneous entities, including theoretical hypotheses, researchers, computer software allowing their mobilization by market professionals, etc.) that frame market reality for their users (by the parameters of the model as much as by its results), thus enabling understanding, calculation, and intentionally rational action (Garcia 2007; MacKenzie 2006; Svetlova 2012). Thus the very market situation that actors find themselves in – who and what exists in the market, how they encounter one another, what sorts of calculations and behaviors are possible – emerges from the ongoing framing performed by devices (Callon and Muniesa 2005; Çalışkan and Callon 2010).

The concept of the market device thus became core to sociomaterial approaches to the market thanks to its accommodation of the heterogeneity and fluidity of economic actors, objects, and environments introduced in Callon’s work. Yet, its limitations soon came into view. One issue, adumbrated in early device-based work, was that the boundaries of devices were ambiguous.² The local, physical components of market devices (e.g. screens, price sheets, trading pits, models) became efficacious only once they were plugged into even wider networks: screens required global information and communication technologies; trading on exchange floor pits required standard protocols for netting and clearing deals; pricing models needed an academic apparatus to give them legitimacy and status (Knorr Cetina 2003; MacKenzie 2006; Zaloom 2006). Some research focused specifically on these secondary elements: not the FICO score mobilized by lenders, but the ‘scorecard’ that brought together the relevant data points (Poon 2007); not the marketing materials that retailers produced to ensnare buyers, but the focus groups that generated knowledge of those consumers in the first place (Lezaun 2007). But these latter analyses did not draw any conceptual distinction between their objects and those that relied upon them. Lumping together these diverse objects as instances of ‘market devices,’ scholars underplayed, rather than explored, their differences.

A second limitation of the concept, noted by political economists, is that device-focused analyses become so wrapped up with tracing sociomaterial minutiae (e.g. how algorithms operate, how screens alter the perception and practices of traders) that they ignore the broader forms of state and corporate power which shape the institutional environment in which devices are constructed and operate (Fine 2003). To focus on the idiosyncrasies of *how* a device is (e.g. the particular make-up of a derivative instrument) obfuscates *why* it is that way (e.g. reflecting the unequal capacity of big financial actors to shape regulation, establish ideological legitimacy, or bully smaller actors) (Mirowski and Nik-Khah 2007). In focusing on the performative effects of market devices, scholars, in fact, uncritically reproduce the economic perspective rather than exposing it for the ideology it is (Erturk et al. 2013; Fine 2005).

The infrastructural turn

These critiques – about the empirical ambiguity and the apolitical narrowness of the device concept – have led researchers by different routes to an appreciation of market infrastructure as an alternative concept. Infrastructure – as it is used in this latest wave of scholarship – refers to the often invisible, sociomaterial networks of ‘boring things’ (Star 1999, 377) that underlie and support mundane, everyday market actions. Infrastructures carry out ‘basic but crucial enabling functions’ that are indispensable to the functioning of the markets concerned (Bernards and Campbell-Verduyn 2019, 776). Whereas screens, reports, and analytics – paradigmatic market devices – are ready-to-hand, accessible, and manipulable elements of the market, infrastructures, by contrast, are not at the surface of action, but deeply embedded in organizational routines and bureaucracies. Functioning infrastructures tend toward invisibility: they ‘seamlessly fade into the background as if natural elements of our human environments’ (Pardo-Guerra 2019, 7). Infrastructures tend to have broad scope, either a physical spanning of distance via information and communication technologies (e.g. submarine cables or satellite networks) or an administrative harmonization via standards, classifications, and protocols (Bowker and Star 2000; Pinzur 2016). This broad scope coordinates action across distant settings, creating a situation where ‘local practices are afforded by a larger-scale technology’ (Star and Ruhleder 1996, 114). Summing up, market infrastructures are understood to differ from devices in a number of ways: they are backgrounded rather than ready-to-hand; operate at a wide scale, connecting multiple settings rather than being purely local; and silently support market actions rather than being manipulable tools.

From this brief description, one can see how the notion of infrastructure addresses the critiques leveled at devices. First, it does not limit itself to a local market component whose boundaries are difficult to define. In fact, it precisely focuses on the broader systems that local devices must plug into in order to operate. Second, it reintegrates the political issue by virtue of its broad, often global, scope. Familiar political-economic actors (states, multinational corporations, international governance regimes) and struggles for control both feature in infrastructural analyses. This positioning in relation to the perceived limitations of the concept of market devices has undoubtedly buoyed the recent ‘infrastructural turn’ in market studies. Infrastructure holds the promise of bridging political economy and social studies of finance, bringing the former’s concerns with state and class power to the analysis of market technology, while applying the latter’s awareness of materiality to macro analyses that tend to be purely institutional in nature (Bernards and Campbell-Verduyn 2019).

Saving the device

This history has meant that the embrace of market infrastructures has mainly come at the expense of engagement with market devices: scholars are focusing on infrastructures *rather than* devices (though notable exceptions are discussed below). As a matter of scholarly attention this shift is not unwelcome: infrastructures have flown under the radar for many years, so there is plenty of material to unearth in empirical research. But as a theoretical position, divorcing market infrastructures from market devices is unsatisfying. As sociologists of finance have noted, infrastructures are critical precisely because they underlie and support everyday, local action, which, itself, is synonymous with the operation of market devices. If infrastructures and devices operate in conjunction, theories that treat them in isolation are surely missing something. Further, while some political economists may have initially been happy to drop device-focused analyses altogether, others argue that this work helps transcend political economy’s ‘narrow conception of the political’ (Braun 2016, 257), and provides a key means for linking the concerns of economic sociology and political economy (Christophers 2014). It appears that using either concept – device or infrastructure – in isolation is insufficient.

Further, the possibilities for synthesis are enhanced by the many similarities between infrastructures and devices. First, infrastructures, like devices, are sociomaterially hybrid assemblages,

featuring both ‘hardware’ and ‘software.’ They are not things, but networks of physical technologies, organizational protocols, standards, and imaginaries (Edwards 2003; Jensen and Morita 2017). Thus, when Pardo-Guerra (2019) talks about the infrastructure of automated stock exchanges, he refers not only to the algorithmic matching engine technology at its heart, but to the cohesive whole this forms with organizational roles, rules about how these can be inhabited, arrangements for determining commissions, and ideas about what makes markets competitive, efficient, and fair. Second, infrastructures, like devices, ‘emerge’ or ‘occur’ through active, organized practices (Bernards and Campbell-Verduyn 2019). The infrastructures that produce market information, for instance, must be sustained through coordinated everyday activity, or ‘database work’ (Özden-Schilling 2016). Finally, like devices, infrastructures actively format the market, defining what it is and what it is not, as well as individuals and their capacities within the market (Pardo-Guerra 2019). As Star (1999, 380) notes, echoing language familiar from device-based work: ‘we see and name things differently under different infrastructural regimes.’ These similarities – sociomateriality, dependence on actualization practices, and situation shaping – demonstrate that both concepts work with a broadly compatible, Callonian ontology. There is no theoretical imperative to choose one concept or the other – in fact, there are grounds for a synthesis.

That is why in this article we consider the articulation between these two concepts. We propose that infrastructures and devices are distinct, but deeply entwined, components of the same networks. Indeed, infrastructures and devices operate in tandem, forming market *agencements*: distributed, sociomaterial assemblages endowed with the capacity to act in the market. Devices and infrastructures are tied together, co-contributing to the ongoing projects of framing the market, enabling calculation, and equipping action. Appreciating these dynamics requires a framework that can both encompass and distinguish between both terms. Embracing the turn to infrastructure requires saving the device, not abandoning it.

Devices and infrastructures: a distinction in two dimensions

The previous section has argued that devices and infrastructures are different components of the same *agencements*. They work in concert to make possible market action. They also are similar in that both are constantly reproduced, sociomaterial networks that define the situation for market actors. Given these similarities and their entanglement in practice, how do we propose to disentangle infrastructures from devices empirically and conceptually, so as to analyze their interactions and evolution? Before offering our own answer, we assess some prior efforts.

Disentangling infrastructures and devices

First, authors have offered general ‘lists’ of the key features of infrastructures that implicitly distinguish these from devices. These vary in the number of elements they list, and variously overlap and diverge in the features they highlight: from infrastructures being relational and political (Kjellberg, Hagberg, and Cochoy 2019), to facilitative and open (Bernards and Campbell-Verduyn 2019), or learned as part of membership and fixed in modular increments (Star 1999). Such lists have two weaknesses for our purposes. First, they tend to be pitched at a general level – i.e. they are not specifically about *market* infrastructures, but might be about computer infrastructures, physical infrastructures, etc. Thus, they do not explore the roles devices and infrastructures play in solving specifically market-based problems (Beckert 2009; Çalışkan and Callon 2010). Second, they focus on infrastructures in isolation, rather than noting their distinctive features in contrast to devices. While they may contain an implicit contrast with more local, everyday elements – described variously as ‘technologies’ or ‘devices’ – they also list several elements that infrastructures share in common with devices (such as their materiality, dependence on actualization, relationality, or political character), and thus do not offer any help in identifying infrastructures’ observably distinctive dimensions.

Other research addresses these shortcomings by explicitly fleshing out the distinction between market devices and infrastructures. A common perspective across these articles is considering market infrastructure as an ‘ecology of interacting devices’ (Pflueger, Palermo, and Martinez 2019, 233). Multiple devices are joined up and articulated to work in concert, forming a sort of ‘super-device’ (Mellet and Beauvisage 2020, 125) that takes on infrastructural qualities. Kjellberg, Hagberg, and Cochoy (2019) offer the clearest empirical illustration of this, showing how a digital market infrastructure for grocery stores formed through the steady harmonization of different individual devices: beginning with barcodes, scanners, and UPC standards, and eventually growing to include redesigned checkout counters, label printers, UPC-compatible scales, scannable coupons, etc. This network of interlinked devices then took on several of the infrastructural characteristics noted above: broad scope, invisibility, enabling new actions. Devices become components of larger infrastructures through a process of absorption and harmonization. This is a view that we endorse and build upon in our own framework.

But this approach to the relation between devices and infrastructures also misses something important. Kjellberg, Hagberg, and Cochoy (2019) demonstrate how multiple parts (i.e. devices) join together into – or, are subsumed within – a cohesive whole (i.e. an infrastructure). What this approach misses is the separate issue of how devices can operate in *conjunction* with infrastructures while maintaining a degree of independence – e.g. the interaction between the customizable computer screens displaying information to a financial trader and the ICT systems feeding them data or the platforms transforming clicks into purchases. Kjellberg, Hagberg, and Cochoy’s (2019) formulation cannot help us to understand, for instance, how grocery store executives seeking out novel profit opportunities will develop, use, and adapt market devices that are explicitly *not* common to the broader infrastructure – yet work in conjunction with it – to aid them in this process. Any perspective on the device-infrastructure relation must encompass such interaction, which was core to the initial turn to infrastructure. Omitting any discussion of this interaction narrows the authors’ perspective on the distinction between device and infrastructure, as well as why it matters.

The analyses from Mellet and Beauvisage (2020) and Pflueger, Palermo, and Martinez (2019) have a different limitation: distinguishing infrastructures and devices in theoretical, rather than empirical, terms. Pflueger, Palermo, and Martinez (2019, 235) tell two ‘stories’ about a single accounting system, treating it first as a market device, then as a market infrastructure. The distinction is based on the two ways that the system contributes to the governance of markets: as a device enabling ‘knowing,’ i.e. rendering visible aspects of the market and its participants, or as an infrastructure that directs ‘thinking,’ the imagining of possibilities and forming of opinions and beliefs. Mellet and Beauvisage (2020) make a different conceptual distinction, arguing that market infrastructures must sustain and frame three key operations: (1) the production and circulation of economically useful information; (2) the capitalization and valuation of economic goods; (3) the coordination of interactions between participants, in the form of exchanges and transactions. Sociotechnical systems that do not do *all* three of these things are not infrastructures, but devices.

These theoretical distinctions, while stimulating, are not a robust foundation for future research. First, they impose unhelpful constraints: If knowing versus thinking, or the trio of information, capitalization, and coordination are *necessary* criteria for distinguishing market infrastructures and devices, then we are compelled to adopt these at the start. If one does not agree with these *a priori* theoretical distinctions (e.g. if we think that both infrastructures and devices are important to both knowing and thinking), then it becomes impossible to make an analysis that brings together infrastructure and device. Second, they are difficult to operationalize. Mellet and Beauvisage’s proposal, for example, raises difficult questions: At what point has a network sufficiently contributed to the solution of these puzzles to be counted as an infrastructure? By our understanding, valuation models – paradigmatic market devices – pass the test: they contribute to the production of knowledge (its outcome clarifying prices for the trader), coordinate actors (who agree on a price), and allow capitalization (the trader’s comparative advantage). A more valuable distinction between

infrastructures and devices would be open to various theoretical claims about their relation, as well as simpler to use.

Our proposal: a distinction in two dimensions

Toward this end, we offer a distinction between infrastructures and devices based on two empirical dimensions of their networks: their extensiveness and optionality. These dimensions allow us to conceptualize devices and infrastructures within the same theoretical framework – i.e. as complementary components of market *agencements* – while still distinguishing their contrasting features. It also is streamlined for empirical application and open to theoretical elaboration, while still encompassing most of the features discussed in the existing literature on infrastructures. Thus, unlike previous attempts rooted in the infrastructure literature, this two-dimensional distinction enables infrastructure- and device-focused research to be bridged, while remaining faithful to most of the work carried out in both.

By extensiveness, we mean simply that infrastructural networks involve comparatively more actants, than device networks. This echoes the ‘ecology of devices’ approach discussed above (Pflueger, Palermo, and Martinez 2019). Market infrastructures result from the ‘successful articulation of various [...] market devices’ into a larger network (Kjellberg, Hagberg, and Cochoy 2019, 228). Generally, this translates into a different geography where infrastructures occupy more space than devices, echoing prior work on infrastructure’s ‘scope’ (Star and Ruhleder 1996) or ‘scale’ (Edwards 2003). (We, however, prefer the term ‘extension,’ which encompasses networks that are densely populated without taking up much space, while excluding those with fewer actants which happen to span the globe.) On the other hand, the device involves fewer actors, often confined within organizational boundaries. In financial markets, for example, a valuation model is – in most cases – doubly idiosyncratic: specific to a type of product (e.g. option, future, equity) and to an organization (Svetlova 2012). It therefore only concerns engineers and traders in a sub-market within a company. This restrictiveness is even more vivid with respect to the spatial organization of trading rooms (Beunza and Stark 2004). While the perimeter of the actants involved remains irreducible to a paperboard or a mathematical formula, *in abstracto*, it is significantly smaller than in the case of infrastructure.

The second dimension of difference we highlight is the optionality of the network. Not only do infrastructural networks envelop a large number of actants, but traders are compelled to engage these networks as a condition of the market they are a part of. Whether they like it or not, financial market participants must rely on the order transmission system and its submarine cables (Pardo-Guerra 2019). This is in line with previous conceptualizations of infrastructures’ ‘ubiquity’ (Mellet and Beauvisage 2020, 111) and the ‘basic but crucial enabling functions’ (Bernards and Campbell-Verduyn 2019, 776) they carry out. Bluntly, it fits Edwards’ (2003, 187) definition of infrastructures as ‘those systems without which contemporary societies cannot function.’ This feature of infrastructure contrasts with devices, which more closely resemble ‘toolkits,’ which, when mobilized, guide actors toward a particular course of action. The use of such devices is less imperative, and more optional. For instance, traders *may*, but need not, choose to mobilize a new valuation model to guide their price interpretation (Stark 2009). It is even often distinctive: recourse to a more sophisticated theoretical model should enable a bank to beat its competitors, that is, to guide its traders toward non-generalized practices.

There are two important clarifications to make. At first glance, the criterion of ‘unavoidability’ comes into tension with that of dependence on actualization practices: If infrastructure is imposed on individuals, how can it still depend on their practices? However, this tension can easily be defused. On the one hand, infrastructure is in a relationship of mutual dependence with those who engage it, even unknowingly, in their everyday work. True, it is not possible to buy a stock without relying on order-matching software, but the latter’s functioning requires it to be constantly fed with buy and sell orders. In other words, while the infrastructure channels access to the market, its ‘grip’ remains dependent on the actions of market participants. On the other hand, any

infrastructure requires the active engagement of a different set of actors who ensure its smooth functioning, e.g. computer engineers employed by exchanges to manage and maintain order-matching software. For these engineers the software is something malleable and changeable – they remain free to choose how they engage with it. This is a key relational point noted in much of the literature: for a network to operate as unavoidable infrastructure for one community, it must remain a flexible, adaptable (and thus non-infrastructureal) system for others.³

The notion of extensiveness similarly seems to clash with the claim of infrastructure's relationality. If relational, infrastructureal networks must always be considered in relation to a given subject position: an infrastructure to whom, for what purposes. 'Extensiveness,' on the other hand, sounds like a particularly objective measure of network size. In fact, though, we do not treat extensiveness as a 'god's-eye' network value, but rather consider it in relation to a community pursuing a particular goal, e.g. investment banks seeking to trade a specific financial instrument. In the pursuit of that goal, this community will mobilize – knowingly or unknowingly – multiple sociomaterial networks. Some of these will be more limited in the number of actants they draw together (e.g. those networks centered around models that enable interpretation and calculation). Others will include a greater number of actants (e.g. those that rely on ICTs and exchange-based platforms to execute their trades). Thus the value of extensiveness is compatible with a relational approach to both infrastructures and devices.

Finally, our two dimensions encompass most of the important characteristics of infrastructures recognized in prior literature. For instance, the *supportive, enabling or facilitative* (Bernards and Campbell-Verduyn 2019; Krarup 2019; Petry 2021; Star 1999) function of infrastructure is covered by our two dimensions: by being more extensive and inescapable, a single infrastructure enables a multitude of devices to operate. Devices, to be effective, need to connect to extensive systems that link them to a vast range of other market actors – i.e. they need to connect to infrastructures. Likewise, extension encompasses infrastructures' *scope, growth from existing systems, availability and durability* (Bernards and Campbell-Verduyn 2019; Kjellberg, Hagberg, and Cochoy 2019; Star 1999); the more that infrastructureal networks expand into multiple communities the more they form a resilient system that can be altered, within constraints and in pieces, but not all at once. Infrastructures' *backgroundedness, transparency, or invisibility* – i.e. the fact that they tend to disappear from consideration in an everyday context is also suggested in our dimensions: extensive, large-scale networks that span multiple sites will likely be difficult to take in all at once; networks that are unavoidable and unalterable likely will not warrant a great deal of close attention.⁴

However, while the dimensions of extensiveness and unavoidability encompass many established infrastructureal features, this is not simply a case of old wine in new bottles. The remainder of this article will explore what this two-dimensional distinction between devices and infrastructure allows us to see and why this matters. In the next section, we argue that the interactions between these two types of networks, as well as their evolution, constitute dynamics at the heart of the functioning of contemporary markets, which our conceptual distinction brings to light. Following that, we draw out their distinct relations to the framing of and power within markets.

Interaction and evolution

A benefit of this two-dimensional distinction is that it allows us to think jointly about devices and infrastructures. More precisely, it helps us to grasp (1) how devices and infrastructures interact, and (2) how they evolve. It thus appears that market *agencements* are both asymmetrical and dynamic: the emergence of devices is constrained by infrastructures which, in turn, can be destabilized by rebellious devices.

The interaction between device and infrastructure

Distinguishing infrastructures and devices by these two dimensions reveals an asymmetry within their interplay as components of a single *agencement*: the infrastructure, more extensive and

unavoidable, defines the perimeter of what can be perceived and counted, which the device then fits into. The infrastructure cannot be avoided, and constrains traders as well as the functioning of devices. For example, a computer programmer who wants to implement new, more efficient software for the automatic processing of interbank communications will have a better chance of succeeding if her proposal is compatible with SWIFT, the messaging system that currently holds a monopoly on the interbank market. The infrastructure, by virtue of its extensiveness and unavoidability, constrains the shape of devices, supporting the operation of those that accept the rules of the game. By joining the market, the device thereby helps to extend the reach of the infrastructure on which it depends: SWIFT increases its inescapability as more banking institutions join.

However, a device which is recalcitrant because it is incompatible with the current infrastructure can become sufficiently successful so as to act as a destabilizing factor, or even impose an amendment to the infrastructure. In such cases, the device network must independently expand, drawing in allies, in order to challenge the asymmetrical position of the infrastructure. While possible, this is particularly delicate because such an extension cannot rely on infrastructural support. Consider, for example, the first algorithms used by small, high-frequency trading companies (MacKenzie 2021). Initially, their emergence was complicated by the NYSE and NASDAQ infrastructure, which published only the best bid and offer prices, while masking the rest of the order book, preventing algorithms from exploiting these signals. In a second phase, however, faced with the emergence of new trading platforms better adapted to high-frequency trading (that is, faced with the extension of a rival network, the possible loss of monopoly and therefore the destabilization of the infrastructure), traditional exchanges amended themselves by publishing their order book. The lesson to be learned from this empirical illustration echoes a finding from Mellet and Beauvisage's (2020) study of Internet cookies: to become part of a wider network, a device needs to surround itself with 'infrastructural partners' and interest them in this collaboration. In this way, the device, while generally dependent on the infrastructure that it helps to reinforce, can become a vector of transformation.

The evolution of device and infrastructure

Giving ourselves the conceptual means to grasp both devices and infrastructures is also essential to understanding their evolution. Infrastructure does not emerge spontaneously or overnight. It can therefore be understood as an ensemble of successful devices that has become indispensable to more and more actors (Kjellberg, Hagberg, and Cochoy 2019). The history of stock market indices represents such an evolution. When they appeared at the end of the nineteenth century, these indices were mainly published by financial newspapers as cognitive tools for their readership (Dutermie 2021). But over time, the network of stock market indices expanded. Firstly, in the 1970s, stock market indices became useful representatives of the 'whole market,' a key concept in the newly popular investment technique of passive management (Bernstein 1993). Then, at the turn of the 1990s, index-based derivatives were developed to facilitate the work of traders at passive asset management companies charged with replicating 'market' performance (Millo 2007). Finally, at the turn of the 2000s, ETFs (Exchange-Traded Funds) enabled the massive spread of index funds, by radically reducing the transaction costs involved in replicating an index (Braun 2016). Today, index derivatives are among the most traded derivatives in the world, and ETFs have propelled passive management, which for the first time is raising more money than active management, to the tune of some \$13.3 trillion (Schmitt 2024). The network of stock market indices has thus 'infrastructuralized,' becoming broad and unavoidable for a large community of actors, including equity traders, asset managers, and more.

However, the status of infrastructure can never be taken for granted. All networks are subject to the threat of shrinking and becoming more optional: in other words, 'de-infrastructuralizing.' Such has been the fate of traditional stock exchanges, which have lost their monopolistic position as default trading venues, notably under pressure from recalcitrant devices such as high-frequency trading algorithms. This could also be the future for the SWIFT financial communications network if a Chinese alternative manages to break through (Nölke 2022). Such could be the case also for

stock market indices if, for example, the critics of passive management obtain strict regulation or even prohibition of index replication, which is the main source of the indices' power. The analysis enabled by the device/infrastructure conceptual distinction must therefore be processual: empirical realities are always in motion, and scholars must be ready to follow the hybridized dynamics of these developments.

This section demonstrates the added value of our two-dimensional distinction, which lets us think about how infrastructures and devices interact, as well as how they evolve from one to the other. First, it enables a clearer articulation between the different components of market *agencements* than exists in much sociomaterial research. Most of the research mentioned previously focuses on a specific object (e.g. an algorithm, a stock index), without integrating it into the network to which it belongs or which it challenges. Research on devices, to avoid confirming the criticism of navel-gazing often leveled at it, has everything to gain from clarifying the place of their object within the market infrastructure. Similarly, to avoid overgeneralization, infrastructure studies should identify the various devices that either extend the grip of their research object within markets or threaten its stability. Our distinction makes this simpler. Secondly, these dimensions also invite us not to freeze the status of our object of study. Market components are always caught up in dynamics of (de-)infrastructuralization. If a researcher examines the current role of stock market indices using the concept of the device as their only analytical grid, they will greatly underestimate the centrality acquired by this infrastructure. Yet this change in status has far-reaching consequences, particularly for the analysis of the power wielded by these networks. This leads us to a third virtue of our conceptual distinction – the asymmetries in power and market framing it makes visible – which the next section of this paper develops.

Framing and power

In this section, we draw on the dimensions of extensiveness and unavoidability to argue that infrastructures and devices – while they work in tandem as entwined elements of broader market *agencements* – differ in the contributions they make to the production of these *agencements*. Specifically, they differ in the types of framing they accomplish ('instrumental' and 'radical') and the forms of power they make possible (the 'discretionary' power of infrastructural actants). This deepens our claim of why the infrastructure-device distinction matters: it builds out the conceptual toolkit with which we can approach the sociomaterial analysis of markets.

Two forms of framing

We can begin this consideration of devices' and infrastructures' roles within *agencements* from an established point: devices exist in a conceptual binomial with framing, i.e. devices establish what is to be taken into account in any economic calculation (see above section 'The critique of devices and emergence of infrastructure'). Given this, market actors often develop and use devices in a quest to produce novel and profitable framings of the market. They engage in bricolage, playing with the arrangement and deployment of screens (Knorr Cetina 2003), trading desks (Beunza and Stark 2004), pricing formulas (MacKenzie 2003), analytical reports (Beunza and Garud 2007; Pollock and D'Adderio 2012) and more, to get an edge on competitors. Instances such as these deliver tools to individuals and often result from a strategic approach, so we refer to them as instances of 'instrumental' framing. Instrumental framing colors participants' reading of reality and guides their actions: it enables them to interpret the state of the market, identify opportunities and calculate courses of action.

Several of the features discussed previously make devices well-suited to the task of instrumental framing. Their limited scope means they are local and easily manipulable; the fact that they are continuously and actively reproduced makes them well-suited to quick adaptation and revision to deal with new market situations. (In Callon's language, they can be quickly adjusted to re-frame any

‘overflows.’) Their optionality means that any device must deal with rival devices that claim to perform the same function through a slightly different framing. This ‘toolkit’ character limits their naturalization: confronted with one device among others, actors are more inclined to engage with them reflexively (Leins 2018). Devices are constantly evaluated, chosen, or passed over in a conscious search for profitable framings within a competitive environment (Erturk et al. 2013).

But we have also seen that devices (limited in scope and optional) rely on infrastructures (expansive and compulsory) to produce whole, operational *agencements*. How then do infrastructures contribute to the process of framing and what are the consequences of this involvement? Clearly, infrastructures’ extensiveness and non-optionality do not permit the local variety or strategic use characteristic of instrumental framing. But this does not mean that infrastructures are uninvolved in framing the market situation, only that their framing takes a different form: what we call ‘radical’ framing.⁵

What makes the framing accomplished by infrastructures ‘radical’ and distinct from that associated with market devices? We can note two features: First, it is a framing that constitutes the shared ontology of the market for all participants; second, it is a framing that is not chosen, but rather imposed on actors as soon as they enter the market. Infrastructures produce ‘novel configurations of the world – new practical ontologies’ that are shared among all users (Jensen and Morita 2017, 618). Infrastructures do not only assign qualities to features of the market but *define* those features for all participants. The infrastructural grades and classes in what Aspers (2009) calls ‘standards markets’ do not simply describe, but rather *become* the goods for sale. Similarly, clearing house infrastructures produce a radical framing where, for all intents and purposes, counterparty risk does not exist for their members (Thiemann 2022). As infrastructures themselves are unavoidable to traders, so are the market framings they produce.

This radical framing also formats the individuals within markets and shapes their capacities, often with long-term consequences. Enframing distinct market positions, infrastructures ‘structure possible fields of action’ (Çalışkan 2020, 542) and ‘endogenously shape practitioners’ economic perspectives’ (Pinzur 2021b, 914). Markets’ infrastructures offer certain affordances for evolution and change, while shutting down others, formatting the actions taken by reformers (Pellandini-Simányi and Vargha 2021). Similarly, infrastructuralized stock market indices have become a standard of profitability against which asset managers’ performances are measured (MacKenzie 2006). Actors, their capacities, and the meanings of their actions are produced via infrastructure’s radical framing.

We should carefully specify these claims. First, as previously noted, infrastructures are not things or given aspects of ‘the environment.’ They must be actively reproduced and are only as solid as their ongoing instantiation through everyday practices – a point which features prominently in the discussion of power below. But so long as an infrastructural system is in operation, it reproduces networks that traders cannot avoid, and which establish the non-negotiable elements of their environment via radical framing. Second, radical framing is not determinative: actors always engage in unpredictable, local, device-based, instrumental framings in pursuit of profit. But the contours established by the market infrastructure do continue to influence everyday actions by shaping market actors and characteristics. Infrastructures serve as ‘limiting causes’ (Wright, Levine, and Sober 1992) that delimit the universe of possibilities for market actors. Finally, the claim that actor-networks configure ontologies is not, itself, new and has long been a feature of device-centered approaches (Latour 2007). The difference when infrastructure networks are involved is the asymmetry of this configuration: the ontology is globally imposed rather than locally produced and establishes contours that further, device-focused elaborations of the network must contend with. This radical reach is made possible by the extensiveness and inescapability of infrastructural networks for everyday action.

Discretion and power

The asymmetry between radical framing – which establishes the unavoidable, shared features of the market – and instrumental framing – which enables particular viewpoints within that market, is reflected in an asymmetry in dependency between infrastructures and devices, where myriad local

devices rely upon a single global infrastructure to operate. Without the radical framing established by infrastructures, device-based instrumental framing would be far less stable and more prone to overflow and collapse, if not altogether impossible. Consider, for instance, how many devices would become inoperable if NASDAQ's order book, Euroclear clearing house, or Bloomberg data services were not working as usual (Duterme 2023; Krarup 2019). How many things would become impossible to do or think as a result? How many devices would fail to achieve valuable instrumental framings? The reverse relation does not hold. Market actors often alter devices without impacting the operation of infrastructures; indeed, they count on that fact. Only under extraordinary circumstances does a shift in devices, through a difficult campaign of network-building, force a change in infrastructure (e.g. the shift to automation and HFT chronicled by Donald MacKenzie). But any change to, or cessation of, an infrastructure's functioning will drastically impact the usage of a device.

This asymmetry means that any actants capable of exercising 'discretion' (Pinzur 2021a) over the continued operation of infrastructures – to do their part or to refuse, to allow connection or not, to work according to one protocol or another – exert outsized power and influence within the *agencements* to which they make essential contributions. This unique discretionary power can take different forms. It can mean controlling others' access to infrastructures. Today, global exchange groups make enormous profits through controlling access to a set of infrastructures – trading platforms, market indices, data services, clearing houses and more – whose absence would cause a crisis of misalignment for traders (Petry 2021). Additionally, this power can appear as discretion over the elements of an infrastructure and how it will run. Actors involved in the establishment of infrastructures make choices about who and what exists in the market. For instance, by determining what countries or companies to include or exclude in their indices, index providers preside over a consequential – and inherently political – process (Duterme 2022; Petry, Fichtner, and Heemskerk 2021). These choices can establish markets that alter capital flows, promoting particular ends and impeding others (Cormier and Naqvi 2023). Finally, discretion can mean the capacity of shutting down the normal operation of infrastructures, so as to force that infrastructure's beneficiaries to adopt changes. For instance, the nineteenth-century Chicago Board of Trade attempted to reshape the system for disseminating market quotations by refusing to supply Western Union with price quotations, thereby disturbing the smooth functioning of the telegraphic infrastructure (Pinzur 2021a). More exceptionally, this discretion can be imposed from the outside, e.g. in the form of protesters using their bodies or other implements to sabotage the smooth functioning of key market infrastructures (Folkers 2017).⁶

This section has traced the implications of infrastructures' and devices' ongoing entanglement for the operation of markets. We argue that devices and infrastructures are associated with distinct modes of framing as well as distinct forms of power. Radical framing and asymmetrical, discretionary power accrue to infrastructural actors on the basis of both infrastructures' distinctive features – extensiveness and non-optionality – and their ongoing relations with market devices. This power associated with infrastructural actors is not exogenous to the market, stemming from, say, their field-level economic or political resources (e.g. the lobbying power of global exchange groups). Rather, it is an endogenous power stemming from the work of radical framing that they do and that is a prerequisite to the collaboration with market devices in cohesive *agencements*. This, then, serves as another reason behind this article's push to 'save the device' – our understanding of this unique form of power comes not only from recognizing infrastructures' differences from devices but also from their ongoing entanglement. Being aware of these distinct modes of framing and forms of power allows us to recognize a set of asymmetrical dynamics that escape notice when our attention is on market *agencements* as singular wholes.

Conclusion

The preceding sections have accomplished the following: (1) Demonstrated the simultaneously distinctive and entwined natures of market devices and infrastructures, and justified our effort at

synthesis; (2) Proffered two dimensions – extensiveness and unavoidability – along which these entangled networks can be empirically and conceptually identified; (3) Highlighted the nature of the interaction between and evolution of infrastructures and devices on the basis of these dimensions; (4) Analyzed the consequences of this interaction and evolution in terms of infrastructures’ and devices’ impact on and power within markets. Overall, we have sought to ‘save the device’ by demonstrating its necessary integration with market infrastructure and highlighting the analytical benefits that stem from considering both as cohesive elements of a single *agencement*.

The paper makes both theoretical and methodological contributions. First, it proposes a new relationship between *agencements*, infrastructures and devices, considering the latter two as entangled components of the first. This makes available for analysis both the asymmetric, intra-*agencement* dynamics at the boundary between infrastructures and devices, as well as the evolution of networks along this boundary. Second, it adds to our understanding of how power operates in *agencements*. We demonstrate a form of ‘discretionary’ power that accrues to infrastructural actors on the basis of their everyday engagement within an *agencement*, distinct from either the micro-level technopolitics of market devices or the power to construct and shape infrastructures that stems from the broader, field-level position of states, corporations, or international oversight bodies. Third, it re-thinks the nature of market framing. Since infrastructures and devices operate in conjunction to produce market *agencements*, both are engaged in framing. We distinguish these forms of ‘radical’ and ‘instrumental’ framing and root them in our two core dimensions of difference. Research that uses only the concept of device or the concept of infrastructure in isolation will miss out on these intra-*agencement* dynamics, forms of power, and distinctions in framing. Finally, the dimensions of extensiveness and unavoidability offer a methodological tool for identifying and studying the interactions and evolutions between infrastructures and devices that is both parsimonious and flexible, while remaining grounded within a processual, network-based, sociomaterial framework on markets.

These contributions suggest areas for reflection in future work. First, it puts forward the boundary, or interface, between devices and infrastructures as a significant, new object of empirical and theoretical concern. Up until now, analyses have oversimplified the relation between devices and infrastructures in two opposing ways: either by failing to draw any distinction between the concepts (e.g. early device-focused work) or by studying one of the two in isolation from the other (e.g. recent work on infrastructure). Our approach, by positioning the interaction of infrastructures and devices as central to our understanding of market *agencements*, brings this boundary to the forefront. This boundary is likely to be a complex space, where multiple, device-affiliated actants pursuing profitable, instrumental framings via bricolage are put into contact with infrastructure-affiliated actants producing longer-term, radical framings.⁷ Despite these distinct motives and groups, infrastructures and devices must cohere. How can we identify and analyze the push–pull relationship this produces? One promising concept with which to address this question is ‘boundary objects’ (Star 2010; Star and Griesemer 1989), which has been taken up enthusiastically in science and technology studies as something of a sister concept to infrastructure, yet has not generally appeared in analyses of markets (Millo and MacKenzie 2009 is the exception that proves the rule). Our analysis suggests its potential as a means of elaborating the link between micro-focused market studies and macro-focused international political economy (Bernards and Campbell-Verduyn 2019; Braun 2016; Christophers 2014).

Second, our analysis provokes a re-engagement with the duality of framing / overflowing (Callon 1998). In associating infrastructures and devices to two distinct modes of framing – radical and instrumental – our perspective suggests two corresponding orientations to overflows. On the one hand, we can imagine that infrastructures – extensive networks entwined with a vast number of day-to-day processes, and tasked with maintaining the broadly shared elements of the market – must vigilantly protect against potential overflows, the presence of which would destabilize core framings that a range of local calculations take as settled. When infrastructures are overflowed the result is not simply profit or loss, but panic: the revelation of LIBOR rate-rigging in 2012 or

of the inaccurate risk scores underlying the production of mortgage-backed securities and their derivatives in 2008 are prime examples. On the other hand, devices might actively seek out or induce small ‘instrumental overflows’ that create a productive ‘dissonance’ (Stark 2009), producing unique viewpoints and catalyzing innovation. These distinctions in the acceptability and utility of overflows, and their relation to the modes of instrumental and radical framing, deserve further scrutiny – particularly at the boundaries where they meet, as discussed above.

Finally, at the broadest level, the article suggests that scholars should always maintain some awareness of the interaction between infrastructures and devices when taking a sociomaterial approach to markets. This is not to say that every analysis must encompass infrastructures, devices, and their articulation in the form of a cohesive *agencement* – this would be unwieldy and burdensome. But we do assert that even when analysis is focused on one or the other, the entanglement of these elements produces important (if not always obvious) dynamics that scholars should note. Device-centered analyses should consider: How are devices constrained by or responding to infrastructures? In what ways are their uses dependent on infrastructures? How does this impact or limit the power and creativity of local actors? How do they maintain flexibility at the boundary with infrastructures? Infrastructure-centered analyses must ask: How are local devices subverting the intended goals of infrastructures? How might they be carving out areas where existing infrastructural networks do not reach or are not compulsory? How, when and why do infrastructures become visible and thus manipulable within local devices (e.g. speed meters on screens)? What are the pathologies that can emerge in the infrastructure – device relation (e.g. mandatory clearing increasing, rather than decreasing, systemic risk)?

The flurry of work on market infrastructures over the past five years has been remarkably fruitful. It has drawn attention to critical objects, actors, and processes that had escaped scholarly view for too long. But further developing the potential of infrastructure requires ‘saving the device.’ The confluence of infrastructures and devices – both conceptually and empirically – promises to be a new, generative frontier in sociomaterial approaches to markets.

Notes

1. A different usage of infrastructure in relation to markets traces back to work coming from political economy. This includes work on ‘institutional infrastructures’ and ‘infrastructural power’ (Mann 1984), as well as the view that treats one market as infrastructural for other broad economic process (e.g. financial markets as infrastructures for allocating money (Clarke 2019)). We focus on the STS lineage here for two reasons. First, there is greater scope for dialogue between this version of the concept and the notion of market device, as they have roots in the same theoretical frameworks. Second, this STS-inflected perspective is receiving more attention in contemporary scholarship, precisely as a way of bridging political economy and sociomaterial market studies.
2. A related issue was that the common usage of ‘device’ to mean a *thing* to be picked up and used by a *person*, each distinct and whole, could lead to some confusion with Callon’s definition of a device as a networked assemblage. This led Callon and others to favor the closely related term *agencement* (Çalışkan and Callon 2010; Muniesa, Mollo, and Callon 2007), which better emphasizes the ways that humans and material objects form unique, agentic networks. While these authors saw this as a purely semantic shift, we, by contrast, argue that devices and *agencements* are not synonymous and must be distinguished.
3. This perhaps aligns us with one particular way of understanding relationality and not another. Prior work tends to divide the ‘infrastructural’ versus ‘non-infrastructural’ relation of actant to network in one of two ways. First, in terms of a perceptual difference: the person who pays attention to the system versus the person for whom it is invisible and unconsidered background. We find this phenomenological distinction both difficult to empirically identify and hard to square with the pragmatist orientation of Callonian sociology. Better is the second perspective, which distinguishes infrastructural relations where the actor *depends on* the network (e.g. the chef who relies the city’s water system when he cooks) and non-infrastructural ones where the actor directly engages the network as a topic (e.g. the structural engineer who maintains the water system). This latter perspective generally aligns with our own: the network is not ‘unavoidable’ to the engineer, as it is for the chef, precisely because the engineer is empowered to alter its form and functioning as part of his day-to-day work. But by conceptualizing these relations in terms of their unavoidability, we more explicitly highlight how the discretion to ‘choose otherwise’ also marks a key difference in actors’ relations to

infrastructure. The implications of this discretion are unpacked in the discussion of ‘discretionary’ power, in the section ‘Framing and power’.

4. However, as with the discussion in FN4, our distinction downplays the perceptual dimension in favor of a pragmatist form. We suggest that this move has a broader benefit of addressing the ‘normalcy bias’ present in much work, where infrastructures are identified in terms of the features they possess ‘when working normally.’ Scholars have already noted the difficulty with applying this framework in developing contexts, where, in fact, the ‘normal’ working of an infrastructure may be that it provides services periodically or unpredictably (Anand 2017). Similarly, a pragmatist orientation makes it possible for infrastructures to come to the perceptual forefront, not just when it fails, but during normal operation. For instance, a particularly curious trader’s awareness of the workings of clearing houses does not undermine their infrastructural quality.
5. Our distinction finds some support in the two contemporary uses of the Goffmanian concept of ‘frame’ (from which Callon’s concept (1998) is inspired). In a usage close to ‘instrumental framing,’ media scholars show how a ‘frame’ is strategically used to ‘select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation for the item described’ (Entman 1993: 52, quoted in Devereux 2007). On the other hand, more akin to ‘radical framing’ (and also to Goffman’s perspective in *Frame Analysis* (1974)), pragmatist sociologists are investigating the principles underpinning the situation and its understanding by participants (e.g. Cefai and Gardella 2012).
6. This is similar to what Farrell and Newman (2019) call ‘chokepoint power,’ though avoiding the unduly topographical metaphor in favor of a term that allows the networked nature of infrastructures to come through.
7. Further contributing to the complexity is that there is not a single, universal, and static boundary to be identified. Thanks to the relationality of infrastructures and devices, one can identify several places at which, for different actors, a boundary exists. We have focused in this article on the ultimate actors – people involved in market transactions and exchanges – but analyses need not focus here. If we look to another group critical to economic action – say, data analysts, lawyers, executives – the boundaries between infrastructures and devices will look different.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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