

Thin Objects: An Abstractionist Account, by Øystein Linnebo. Oxford: Oxford University Press, 2018. Pp. xviii + 238.

Abstractionism, in the philosophy of mathematics, seeks to accord a special status and foundational role to axioms of a certain kind. Two of the best known examples of an *abstraction principle* originate in the work of Gottlob Frege—Hume’s Principle and Basic Law V:

- (HP) the number of F s = the number of G s iff the F s and the G s are equinumerous
 (BLV) the extension of F = the extension of G iff F and G are coextensive

A generalized-version of the second axiom is central to the famous, failed logicist programme of his *Grundgesetze der Arithmetik* where, as we all know, Frege sought a purely logical basis for arithmetic, and found Russell’s paradox.

Nowadays, the dominant species of abstractionism—which Linnebo’s book challenges—aims to rescue something of Frege’s programme from the logical wreckage by shifting its focus to axioms other than (BLV). In general, an abstraction principle states a ‘criterion of identity’ for abstract objects of a given kind (p. 35):

- (AP) $\S\alpha = \S\beta \leftrightarrow \alpha \sim \beta$

In the axiom, ‘ $\S\alpha$ ’ and ‘ $\S\beta$ ’ are (complex) singular terms, intended to denote the relevant abstract objects; the variables ‘ α ’ and ‘ β ’ range over entities of a given type, which—in Linnebo’s terminology (p. 35)—serve as ‘specifications’ of the corresponding abstract objects; and ‘ $\alpha \sim \beta$ ’ expresses a ‘unity relation’ on the specifications.

Crispin Wright and Bob Hale’s well-known neo-Fregean programme resurrects an idea Frege had earlier rejected in his *Grundlagen der Arithmetik*. On this view—in good cases—an abstraction principle serves as an ‘implicit definition’, whose free stipulation results in an *a priori* truth. The interest of this striking claim, if it can be sustained, is underwritten by an equally striking technical result. *Frege’s Theorem* states that, given Frege’s definitions of ‘natural number’, ‘zero’, and so on, the axioms of Dedekind–Peano arithmetic—PA—may be derived from (HP) in an appropriate second-order logic. (See, e.g., Wright and Hale 2001, pp. 4, 14, 279.)

The neo-Fregean version of abstractionism raises a number of interesting and difficult questions:

- (Q1) Why think that some abstraction principles, such as (HP), enjoy a privileged epistemic status not shared by, say, the axioms of PA?
 (Q2) Can a principled distinction be drawn between these ‘good’ abstraction principles and their ‘bad companions’, such as BLV (the *bad company problem*)?
 (Q3) Does the abstractionist approach successfully extend to branches of mathematics other than arithmetic (e.g. Zermelo–Fraenkel set theory, ZF)?

Wright and Hale’s radical reshaping of Frege’s logicism into the neo-Fregean programme has been hugely influential, prompting hundreds of articles and book chapters addressing these questions, and many others. Linnebo’s wonderfully inventive and richly detailed book could well ferment a second abstractionist revolution. Linnebo departs at least as much from the neo-Fregeans as they do from Frege, rethinking abstract reference and epistemology from the bottom up. The ‘thin’ view of abstract objects and the ‘dynamic’ view of abstraction that emerge open up some badly needed new avenues of response to much-discussed questions, including (Q1)–(Q3). At the same time, Linnebo’s book denies that any plurality of items make up an absolutely comprehensive domain of quantification and abandons Frege’s route to the natural numbers, raising no shortage of difficult and interesting questions of its own. All in all, this approach calls for a wholesale reappraisal of abstractionism.

This is a dauntingly large task. Drawing on almost two decades of research, however, Linnebo’s book covers an impressive amount of ground, setting issues in metaphysics and epistemology on equal footing with those in logic and mathematics. The book is split into three parts, which develop and refine—and, occasionally, revise—his earlier views, incorporating a substantial quantity of new material. Chapters 1–3 give an accessible overview of the main components of Linnebo’s view; Chapters 4–7 offer comparisons to related views espoused by Agustín Rayo (2013), the neo-Fregeans, and Frege himself; and Chapters 8–12 further elaborate on some of the core arguments and technical details (the latter of which are further explored in appendices attached to most chapters). Let’s follow the ‘*via brevissima*’ that Linnebo lays out for his readers in the first part of the book, pausing on some points of interest, before returning to (Q1)–(Q3).

The first chapter characterizes the titular ‘thin objects’ with the help of some fairly heavy duty metaphysics. An object is *thin* if ‘a comparatively weak claim—not ontologically committed to the object in question—nevertheless *suffices* for the existence of the object’ (pp. 42–3). Sets provide one *prima facie* example (p. 4). This is because, on a view like Linnebo’s, the claim that there is a plurality of items (e.g. Frege and Russell) *suffices* for the existence of their set—{Frege, Russell}—even though this claim is not *ontologically committed* to the set (in the Quinean sense operative in Linnebo’s book, p. 13). The relevant notion of sufficiency is a ‘species of metaphysical grounding’ (p. 18) which is ‘less demanding than analytic implication but more demanding than strict implication’ (p. 17). For some thin objects—for example, pure sets: \emptyset , $\{\emptyset, \{\emptyset\}\}$, ω , ε_0 , \aleph_α , V_β , and so on—the weak claim that suffices for the thin objects’s existence is a tautology with no ontological commitments. In this case, the object is *absolutely thin* and its existence is a ‘free truth’ (pp. 13, 103).

Needless to say, Linnebo is no nominalist. Indeed, according to Linnebo (pp. 9–11), much of the appeal of thin objects is bound up with the view that mathematical theories (arithmetic, set theory, and so on) should be taken at ‘face value’ as bodies of truths which refer to, and quantify over, abstract objects (natural numbers, sets, etc.). The distinctive benefit of taking the abstract objects to be thin objects is to assuage epistemological worries that would otherwise attach to this ontology (which we return to when we come to discuss (Q1)).

Abstraction principles enter the picture in Chapter 2. At the core of Linnebo’s pre-

ferred, abstractionist, account of thin objects are two ideas he attributes to Frege: that ‘being a possible referent of a singular term *suffices* for objecthood’ (p. 25) and that ‘singular reference can be explained in terms of the concept of a criterion of identity’ (p. 22).

To elaborate, imagine, for instance, a speaker who uses terms like ‘ l_1 ’ and ‘ l_2 ’ to refer to (concrete) lines and grasps the parallelism relation (symbolized: \parallel), but whose language lacks the resources to refer to or quantify over abstract objects. According to Linnebo, she may come to speak *as if* there are directions by introducing would-be direction terms such as ‘ $d(l_1)$ ’ and ‘ $d(l_2)$ ’, and using the abstraction principle (Dir), and appropriate ‘inheritance’ axioms, to specify *assertibility conditions* that ‘govern her discourse’ about directions (p. 37):

$$(\text{Dir}) \quad d(l_1) = d(l_2) \leftrightarrow l_1 \parallel l_2$$

In her newly extended language, for instance, ‘ $d(l_1) = d(l_2)$ ’ is assertible precisely when the lines denoted by ‘ l_1 ’ and ‘ l_2 ’ are parallel; ‘ $d(l_1)$ is orthogonal to $d(l_2)$ ’ precisely when they are perpendicular, and so on (p. 34).

Linnebo’s key claim is that, when properly developed, this kind of linguistic practice leads the speaker’s extended language to be so interpreted that she, in fact, *refers* to abstract objects. Moreover, this renders the right-hand side of (Dir)—which is free from ontological commitment to directions—*sufficient* for its left-hand side, which is not (p. 37). In this way, unproblematic facts about lines underwrite the existence of directions, as thin objects, and axioms such as (Dir) emerge as ‘free truths’ in the extended language (p. 103). Likewise, letter-types may be ‘abstracted’ from their tokens (pp. 135–43), ordinals from the sequences whose length they measure (pp. 183–5), sets from their elements (pp. 58–9), and so on.

Is abstract reference really this easy? How could speaking *as if* there are items of a certain kind suffice for their existence? The details follow in Chapters 8 and 9. Chapter 8 argues that, if it is available, a *non-reductionist interpretation*, where the relevant abstract terms ‘ $\S\alpha$ ’ and ‘ $\S\beta$ ’ refer to abstract objects, is preferable to a *reductionist interpretation*, where they do not. The non-reductionist interpretation better integrates with the standard semantics for generalized quantifiers and meets a plausible cognitive constraint on interpretation in cases where the reductionist interpretation does not (pp. 143–8). Chapter 9 extends this account to deal with contexts such as ‘ $\S\alpha = \text{Julius Caesar}$ ’.

There’s room here for Linnebo’s opponent to contest some of the details. But many nominalists may well accept that the existence of abstract objects *would* make for a smoother semantics. The crucial question is whether, as Linnebo further argues (pp. 41–2, 148–51), a non-reductionist interpretation is even *available*. After all, as he observes, the nominalist can be expected to object to his key sufficiency claim that ‘a line and parallelism suffice to specify a direction’ on the grounds that ‘there simply are no directions’ (p. 41). Linnebo’s initial response is to double down on his sufficiency claim: ‘There is no alternative, more direct or secure way of specifying a direction than what we have already offered’ (pp. 41–2).

Is there a way to forestall the looming impasse? Linnebo suggests we look to a ‘structurally analogous’ dispute (p. 42). The case in question concerns reference to ‘physical bodies’ (in a marketplace ‘Spelke-object’ sense (p. 27, n. 14) which includes stones and tables but excludes many of their non-detached parts and typical stone–table fusions). The nominalist may immediately be drawn to the obvious disanalogy: unlike directions, physical bodies are not causally inert. But Linnebo makes the case that there’s more to reference than a simple causal relation (pp. 26–30).

In virtue of what does a referential novice come to refer to *the table*, rather than that part of its surface with which they directly interact, or some other object which has this ‘parcel of matter’ as a part? In Linnebo’s view, ‘a capacity for grouping together . . . pieces of information just in case these pieces derive from parcels that are spatiotemporally connected’ plays a central role (p. 28): ‘To specify a physical body, it suffices to have causally interacted with one of its parts and to be operating appropriately with the relevant unity relation’ (p. 42). Moreover, there is no more direct way to “get at” a physical body (p. 29). Any challenge to refer to the body in ‘a more direct or secure way’ should simply be rejected (p. 42).

Should the nominalist challenge to abstract reference likewise be seen as an instance of unreasonable scepticism, as Linnebo suggests (p. 42)? Hardline nominalists may accept that direction reference is *no more problematic* than physical body reference, and defend the reasonableness of rejecting both. Their more moderate counterparts may instead prefer to challenge the analogy and defend an alternative, non-abstraction-based account of reference to physical bodies. As with scepticism, however, Linnebo feels no obligation to defeat the nominalist *on her terms*. His primary focus is instead on developing an appealing anti-nominalism.

This brings us to Chapter 3, which outlines the dynamic account of abstraction Linnebo defends. The principal logical differences between Linnebo’s account and neo-Fregean abstractionism come out clearly in the context of the bad company problem. Consider, for instance, a plural variant of (BLV) (pp. 57–8):

$$(V) \quad \{xx\} = \{yy\} \leftrightarrow \forall u(u \prec xx \leftrightarrow u \prec yy)$$

In the axiom, xx and yy are plural variables, which (under an assignment) each denote zero or more items. Following Linnebo, we adopt the convention of speaking of such *items* as ‘a plurality’ regardless of whether they make up a set or set-like collection. The formula $u \prec xx$ formalizes ‘ u is one of xx ’ and $\{xx\}$ formalizes ‘the set of xx ’.

On the neo-Fregean view, (V) is a blatant example of a bad companion. As Linnebo observes (p. 59), given natural definitions of membership and ‘plurality uu forms set x ’ (symbolized: $\text{SET}(uu, x)$), (V) gives rise to a plural formulation of naive set theory:

$$\begin{aligned} (\text{COLLAPSE}) \quad & \forall uu \exists x \text{SET}(uu, x) \\ (\text{EXT}) \quad & \text{SET}(uu, x) \wedge \text{SET}(vv, y) \rightarrow (x = y \leftrightarrow \forall z(z \prec uu \leftrightarrow z \prec vv)) \end{aligned}$$

And these axioms lead to Russell’s paradox, given the instance of ‘plural comprehension’ stating that some plurality comprises every non-self-membered set (pp. 62–3):

$$(3.5) \quad \exists rr \forall u(u \prec rr \leftrightarrow u \notin u)$$

The mainstream neo-Fregean response is to seek a principled distinction between good abstraction principles like (HP) and their bad companions, such as (V) and other more subtly problematic abstraction principles. But with ‘no consensus in sight’ after ‘decades of work’, Linnebo is justifiably pessimistic about this strategy, especially since recent accounts in this mould have ‘lost touch’ with the underlying account of how abstraction functions (p. 55).

Linnebo (pp. 55–60, 98–103) instead proposes to rehabilitate forms of abstraction deemed ‘bad’ on the neo-Fregean account, by taking abstraction principles to have a ‘predicative’ character (p. 97): on this view, unlike on the neo-Fregean account, the abstract items that (V) serves to introduce—the items that ‘ $\{xx\}$ ’ and ‘ $\{yy\}$ ’ denote—are not assumed to lie in the domain of the quantifier $\forall u$ used to express the unity relation on its right-hand side. Instead abstraction is accorded a ‘dynamic’ character (p. 52). Given an arbitrary set or plurality D serving as the initial domain, predicatively abstracting with this unity relation introduces more sets than there are members of D , resulting in a *more inclusive* domain D^+ , which may then serve as the basis for further rounds of predicative abstraction (pp. 60–1). Predicativity (in this sense) restores (V) to good standing (p. 59), and forms the basis for a response to the bad company problem which ‘accepts abstraction on just about any equivalence relation’ (p. 52).

The price for blocking Russell’s paradox in this way—since we may use (V) to enlarge *any set- or plurality-domain* with further sets—is to deny that any such domain comprises absolutely every item that can be introduced by abstraction. Nonetheless Linnebo maintains that we can describe the resulting *potential hierarchy* of sets using ‘interpretational’ modal operators \Box and \Diamond , which unlike metaphysical modality concern possible variations in interpretation rather than circumstance (p. 61):

$\Box\phi$: ‘no matter what abstraction steps we carry out, it will remain the case that ϕ ’

$\Diamond\phi$: ‘we can abstract so as to make it the case that ϕ ’

Iterated abstraction sustains not COLLAPSE, but the ‘modalization’ of this axiom (p. 62):

$$(\text{COLLAPSE}^\Diamond) \quad \Box\forall uu\Diamond\exists x\text{SET}(uu, x)$$

The modal axiom tells us that, for any plurality which becomes available through any number of rounds of abstraction, its set *can always* be ‘formed’ by further abstraction. Notwithstanding Linnebo’s repudiation of an absolutely comprehensive set- or plurality-domain, modalizing formulas in this way—replacing their singular and plural quantifiers \forall and \exists with ‘modalized quantifiers’ $\Box\forall$ and $\Diamond\exists$ (p. 64)—recovers a modal kind of absolute generality (pp. 64–6). Chapter 12 goes on to show how the ‘sound core of naive set theory’ (p. 63)—based on the modalized axiom COLLAPSE^\Diamond —can be extended to obtain a theory MS that interprets ZF.

To return to our earlier questions, dynamic abstraction is well-placed to give attractive answers to (Q2) and (Q3) (concerning bad company and set theory), but not without some qualification. In the case of bad company, the switch from (BLV) to the plural axiom (V) is noteworthy. The ‘simple and definitive’ solution (p. 96) offered for abstraction

on extensional pluralities (compare Studd 2016) does not straightforwardly generalize to intensional concepts, under which yet-to-be-abstracted items may fall (compare Linnebo 2009). In the case of set theory, it's important to take account of the additional axioms MS encompasses. Linnebo helps himself to the ZF-axiom Foundation as part of MS, and draws on a replacement principle for pluralities and a modal reflection principle to recover further ZF-axioms (namely Replacement and Infinity). We might do without Foundation if we help ourselves to a further modal operator (p. 213, n. 10, Studd 2019, ch. 6). But we cannot hope to fulfil anything like the epistemological ambitions neo-Fregeans may harbour for ZF unless we can secure the good epistemic standing of whatever additional axioms are used to push the hierarchy beyond finite stages.

This brings us back to (Q1) (concerning epistemology). Linnebo rejects a Benacerraf-style demand to integrate a causally-inert abstract ontology with a causal theory of knowledge: an across-the-board causal requirement would be 'sheer philosophical prejudice' (p. 197). Nonetheless, Linnebo takes mathematicians to be highly reliable. For a suitable choice of mathematical theory Σ , formulated in a language \mathcal{L} , he endorses the following 'reliability claim' (p. 202):

(R) For nearly all sentences S of \mathcal{L} , if mathematicians accept S , then S is true.

This gives rise to an epistemological challenge levelled by Hartry Field (1989): how is the anti-nominalist to explain mathematical reliability?

A 'boring' would-be explanation is available. This proceeds by factoring (R) into two components (p. 203):

(R_B) For nearly all sentences S of \mathcal{L} , if mathematicians accept S , then S is in Σ .

(R_T) For all sentences S of \mathcal{L} , if S is in Σ , then S is true.

On this account, (R_B) holds because mathematicians accept Σ , and (R_T) holds because Σ is a true theory. But in this case why think it more than a happy coincidence that mathematicians have come to accept a true theory?

To forge a connection between (R_B) and (R_T), Linnebo instead looks to his account of abstraction. On his view—in the case where Σ is an *elementary theory of abstraction* that describes the 'free truths' in the extended language which result from a single round of predicative abstraction (p. 103)—acceptance and truth have a common antecedent. When mathematicians accept a true sentence S of Σ , the *assertibility conditions* that govern their discourse about the relevant abstract items provide a causal, psychological account of why S is accepted and a constitutive, metasemantic explanation of why S is true (p. 203).

Advocates of the 'boring' explanation may challenge whether Linnebo's account fills a genuine explanatory gap (see, e.g., Burgess and Rosen 1997, sec. I.A.2.c); but even assuming it does, it's clear that his abstractionist strategy limits the scope of the putative explanation. Unlike its competitor, Linnebo's explanation is only immediately available in the special case when Σ is an elementary theory of abstraction of the kind just described.

How much mathematics might such a theory contain? On the face of it, not very much. Linnebo is clear that, if abstractionism is to attain its broadly Fregean epistemological goals, the abstractionist is not entitled simply to *assume* that the initial domain is infinite (p. 104). On the other hand, starting from a finite initial domain, predicative (HP) only gives rise to finitely many cardinals (p. 61); predicative (V) only gives rise to finitely many sets. This is no basis for PA, let alone ZF, or Linnebo's modal theory, MS.

To overcome the weakness of predicative abstraction principles, Linnebo proposes, as we saw above, to 'iterate steps of predicative abstraction' (p. 106). But what is the *epistemic status* of mathematics obtained from *iterated* predicative abstraction? Linnebo claims that any finite number of iterations pose 'no particular problem' provided 'we allow for our epistemic abilities to be suitably idealized' (p. 202); but he concedes that the infinite case requires 'an altogether different form of idealization' so that 'our justification for the resulting statements will be more indirect and less conclusive' (p. 202).

In the infinite case, this seems to put it mildly. If the proposal is that knowledge or justified belief in the axioms of PA (or ZF) may be obtained by carrying out the *infinitely many* (inaccessibly many?) rounds of predicative abstraction required to recover this theory, Linnebo has carved out an epistemic channel fit only for deities. Even if infinite beings who are capable of such a supertask (hypertask?) *could* obtain knowledge or justification in this way, why think *any* of it rubs off on us.

Is there another way? Chapter 10 defends an ordinal account of arithmetic where natural numbers are abstracted from concrete numerals, with a specified position in a suitable ordering, rather than identified with finite cardinals as on the neo-Fregeans' (HP)-based account. At first sight, this appears to exacerbate the finitude problem. For unless ordinal abstraction increases the stock of *concrete* numerals, iterated abstraction becomes pointless: all the ordinals that can be abstracted from the fixed stock of specifications are introduced by the first round.

A different route is open for Linnebo to break through the finitude barrier, however. So far we have assumed, in line with neo-Fregean orthodoxy, that the only items that are obtained from abstraction (at a given possible world) are those for which a suitable specification exists (at that world). Call this the *actual specification view*. On this view, a given finite ordinal would not exist unless the world supplies a large enough stock of concrete numerals to instantiate the corresponding ordering. But Linnebo is clear that he takes the standard view that natural numbers, and other pure mathematical objects, exist necessarily (pp. 188, 190). How is this thesis to be sustained if pure mathematical objects are abstracted from contingently existing concrete specifications?

The answer appears to be that, at least in some cases, Linnebo endorses what we may call the *possible specification view*. On this view, items are abstracted from both actual and merely possible specifications, so that—after a single round of abstraction—the *possible existence* of the specification suffices for the *actual existence* of the corresponding abstract. In the case of ordinals, Linnebo observes that the 'numerals witnessing the existence of the numbers could exist anywhere' (p. 190). But this only secures the existence of ordinals specified by no sequence of actual concrete numerals if 'anywhere' extends to merely possible locations. In the case of directions, he is explicit on this point: 'the existence of a direction does not require that there must *actually* exist a line

that instantiates it; it suffices that there *possibly* exists such a line' (p. 45).

The possible specification view has a clear upside: on the plausible assumption that sequences of concrete numerals of any finite length are possible, a single round of abstraction suffices to introduce the infinitely many finite ordinals needed to recover PA.

But the possible specification view also has two notable downsides. First, there is a metaphysical concern. In many cases, this view seems to make thin objects *too thin*. Combined with an abstractionist account of sets, for instance, the possible specification view has it that the possible existence of the plurality of its elements suffices for the set {Frege, Russell} to exist even in worlds where Frege and Russell do not. This conflicts with the widely held view that an impure set exists only if its elements do.

Second, and more worryingly, there is a logical problem. The possible specification view casts doubt on Linnebo's means for avoiding Russell's paradox. Much like in the non-modal case, the axioms (COLLAPSE[◇]) and (EXT[◇]) lead to Russell's paradox in the underlying modal plural logic if we assume a modalized instance of plural comprehension (pp. 66–7):

$$(3.5^\diamond) \quad \diamond \exists rr \Box \forall u (u \prec rr \leftrightarrow u \notin u)$$

The crux of Linnebo's response (pp. 67–8) to the paradox is to reject the pathological instances of modalized plural comprehension. The modal claim (3.5[◇]) tells us, in effect, that iterated abstraction eventually leads to a (plurality-) domain D , a plurality of whose members make up absolutely every non-self-membered set that can ever be introduced by abstraction. On Linnebo's account of the potential hierarchy, however, this is false: additional rounds of abstraction permit us to introduce further non-self-membered sets that lie outside D .

The trouble is that this means to avoid Russell's paradox relies on the actual specification view. If instead sets may be abstracted from both actual and merely potential pluralities, a single round of abstraction suffices to simultaneously introduce absolutely every set, flattening the entire potential hierarchy into a single plurality-domain, D_∞ . The non-self-membered sets in D_∞ then witness the pathological formula (3.5[◇]), which restores Russell's paradox in conjunction with the other axioms in MS.

Two options are apparent: (i) Linnebo could ban abstraction on merely possible specifications across the board. In this case, if he is to avoid the epistemological problems with infinitely iterated abstraction, he needs another way to ensure the necessary existence of pure mathematical objects and another way to obtain an infinite stock of natural numbers. Alternatively, (ii) he may uphold the possible specification view in 'good' cases and reject it in 'bad' ones. This brings back something much like the bad company problem and, as in that case, we should expect the good–bad distinction to flow from the underlying account of abstraction. If a language equipped with modal operators permits us to frame assertibility conditions for 'ordinal'-talk so as to abstract ordinals from *metaphysically possible* sequences, why do the analogous assertibility conditions for 'set'-talk not also permit us to abstract sets from *interpretationally possible* pluralities? After all, these are every bit as extensional as their actual counterparts.

J. P. STUDD

Lady Margaret Hall, University of Oxford
james.studd@philosophy.ox.ac.uk

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