

# Psychological Barriers to Sustainability:

## Understanding Consumer Demand for Products with Redundant Functionalities

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### Abstract

Despite the proliferation of multifunctional products, survey data suggests that instead of relying on one multifunctional product, consumers now rely on a community of multifunctional products, using them interchangeably to perform similar tasks. Such consumption patterns stand in stark contrast to consumers' well-documented aversion towards waste. Why are consumers willing to dispose of multifunctional products that still have some working capabilities and/or pay for functional redundancies? We suggest that controlling for the absolute level of performance (e.g., the megapixels of the camera), consumers perceive the same functionality to be less valuable when it is performed by a multifunctional product (e.g., the camera on a smartphone) than by a single, dedicated product (an inexpensive digital camera). We investigate this phenomenon across a series of four experiments which are aimed at documenting the basic effect and elucidating the underlying psychology.

## Psychological Barriers to Sustainability:

### Understanding Consumer Demand for Products with Redundant Functionalities

Many products today are multifunctional. For example, there are roughly 4.3 billion smartphones currently in use (Gartner, 2021), and each possesses the functionality of a phone, a computer, a web browser, a camera, a GPS, a language translator, a scanner, etc. Several scholars and journalists have suggested that the adoption of products with multifunctional capabilities should ultimately lead to more environmentally sustainable outcomes through dematerialization and reductions in raw material use and waste (O'Connell, 2013). Whereas consumers once needed a separate, dedicated product for each individual task, in many cases, they can now rely on a single product to perform several different functions (Kasulaities, 2021).

Despite the proliferation of multifunctional products, however, survey data suggests that instead of relying on one multifunctional product, consumers now rely on a community of multifunctional products, using them interchangeably to perform similar tasks (Ryen et al. 2014; 2015; Kasulaities, 2021). For example, a consumer may start watching a drama series on her laptop, switch to her tablet, and eventually finish up an episode on her smartphone. Moreover, even though multifunctional products such as smartphones are by no means cheap, most smartphones are replaced more frequently than T-shirts, despite being in good working condition (Geyer & Blass, 2010; Wieser & Tröger, 2017, Makov & Fitzpatrick, 2021). Such consumption patterns stand in stark contrast to consumers' well-documented aversion towards waste (Arkes, 1996; Bolton & Alba, 2012; Sun & Trudel, 2016). This raises the question, why are consumers willing to dispose of multifunctional products that still have some working capabilities and/or pay for functional redundancies?

1           In this paper we investigate one psychological antecedent of this phenomenon.  
2           Specifically, we propose that these costly consumption patterns are enabled by consumers'  
3           tendency to undervalue the individual capabilities of a multifunctional product (e.g., the phone,  
4           GPS, and camera on a smartphone) relative to when those same functions are each performed by  
5           standalone products (e.g., a dedicated mobile phone, dedicated GPS, and dedicated camera). Put  
6           differently, we suggest that controlling for the absolute level of performance (e.g., the  
7           megapixels of the camera), consumers perceive the same functionality to be less valuable when it  
8           is performed by a multifunctional product (e.g., the camera on a smartphone) than by a single,  
9           dedicated product (an inexpensive digital camera). These differences in perceived value, may in  
10          turn, have important downstream consequences in terms of reuse and disposal, and may  
11          discourage consumers from considering older multifunctional products as reasonable substitutes  
12          for new, single-function products. For example, new parents may purchase a separate, dedicated  
13          baby monitor rather than use the working camera on a discarded smartphone that they already  
14          own.

15          Ignoring the potential to repurpose multifunctional products is costly for both consumers  
16          and the environment. Indeed, the macro-level implications of such behaviors are potentially great  
17          as the fast replacement rate of multifunctional products and the purchase of multiple products  
18          with redundant functions increases the overall throughput of materials, energy, and waste. For  
19          example, the climate change impacts associated with a single iPhone 12 amount to 70kgCO<sub>2</sub>-eq  
20          (Apple, 2020), and each smartphone makes use of over 75 different elements of the periodic  
21          table, many of which have very low recycling and recovery rates, including a variety of precious,  
22          critical, and conflict minerals whose mining has been linked to civic unrest (Reck and Graedel,  
23          2012).

1           In sum, we suggest that despite the numerous environmental benefits that are afforded by  
2 multifunctional products, and the sustainability benefits in terms of material reduction and reuse,  
3 there may be unforeseen psychological barriers which prevent consumers (and producers) from  
4 capitalizing on these benefits. We investigate this phenomenon across a series of four  
5 experiments which are aimed at documenting the basic effect and elucidating the underlying  
6 psychology.

### 7 *Devaluing Multifunctionality*

8           The existing literature in psychology and marketing identifies several converging  
9 explanations for why the same capabilities may be thought of as less valuable when performed  
10 by a multifunctional product versus a collection of single-function products. One mechanism  
11 stems from a phenomenon known as the “zero-sum” heuristic (Chernev, 2007). The basic notion  
12 is that consumers tend to assume that the resources which a firm uses to manufacture a product  
13 are fixed. As a result, product enhancements in one domain may be seen as detracting from  
14 benefits in another domain. For example, if a toothpaste is advertised to have enhanced tooth-  
15 whitening capabilities, consumers may infer that it is less good at cavity-protection.

16           To date, the zero-sum heuristic has been primarily documented in cases where a single  
17 product (like toothpaste) offers multiple benefits. However, Newman, Gorlin & Dhar (2014)  
18 found that such inferences may also persist in cases where the benefits are in different conceptual  
19 domains—e.g., making a cleaning product better for the environment may lead consumers to  
20 perceive it as less effective. Therefore, it may that similar inferences extend to cases where a  
21 multifunctional product has different dedicated functions, such as smartphone, or a 3-in-1  
22 printer. Here, due to the “zero-sum” heuristic, consumers may perceive that each of the  
23 dedicated functions performed by a multifunctional product are less capable than the comparable

1 functions of a single-function product, and as a result, may value the multifunctional product less  
2 than the sum of its' single-function parts.

3           A second explanation is associated with the phenomenon of “mental accounting.”  
4 (Thaler, 1985). In brief, mental accounting argues that consumers tend to think of money  
5 differently depending on its intended use or source. In the context of multifunctional products,  
6 this may mean that damage or outdated capabilities associated with one of the product’s  
7 functions may “taint” the perceived capabilities of the product as a whole. For example, a  
8 consumer may replace a perfectly functioning smartphone with a newer model just because they  
9 perceive the camera to be out-of-date. Analogously, consumers may create distinct mental  
10 accounts which budget for the same capabilities across multiple products—a consumer may  
11 construe a mental budget very differently for a smartphone verses a camera they budget. As a  
12 result, consumers may be less likely to perceive functional redundancies across different mental  
13 accounts.

14           A third mechanism may be that consumers intuitively perceive a correlation between  
15 value and the amount of material *stuff*. In other words, a collection of single-function products  
16 are comprised of more physical material than a comparable multifunctional product, and as a  
17 result, consumers may perceive the collection of single-function products to be worth more.  
18 Thus, whereas multifunctional products have environmental benefits because they typically  
19 require fewer material inputs than single-function products, they may ironically be perceived as  
20 less valuable by consumers for the very same reason.

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1 more than once (based on repeating IP addresses), were excluded from the study ( $N=52$ ). The  
2 remaining 188 participants (54.8% male;  $M_{age}= 36.1$ ), were randomly assigned to one of two  
3 between-subjects conditions: multifunctional product versus single-function products.

4 Specifically, participants were asked to imagine they had a home office, equipped with  
5 various devices. Half of the participants were told that their home office was equipped with a  
6 separate printer, copy machine, and fax machine (single-function condition), while the other half  
7 of participants read that their office had a 3-in-1 printer, photocopier and fax machine  
8 (multifunctional condition). Critically, in both conditions the original price paid for the three  
9 devices, or the 3-in-1 device, was the same (\$275). All participants then read that the fax machine,  
10 which they used only occasionally, had stopped working (though the printer and photocopier  
11 worked fine).

12 Participants were then asked to state the lowest sum of money (in \$US) they would be  
13 WTA to sell the equipment. No upper or lower limits were imposed, and participants were free to  
14 state their WTA as they saw fit. Past work suggests that when selling products, consumers tend to  
15 specifically focus on what they are potentially giving up in the exchange (Carmon & Ariely, 2000).  
16 Hence, in this case, we expected that consumers' WTA would directly reflect their valuation of  
17 the photocopier and printer.

### 18 *Results and discussion*

19 The results indicated that valuation of the multifunctional product ( $M= \$116.8$ ,  $SD=51.7$ )  
20 was significantly less than the single-function products ( $M=\$138.6$ ,  $SD=55.6$ ),  $t(186)=-2.77$ ,  $p=$   
21  $.006$ ,  $d=0.4$ . These results indicate that the same remaining functions (i.e., printer and photocopier)





1 remaining 175 eligible participants (66.9% male;  $M_{\text{age}} = 36.2$ ) were randomly assigned to one of  
2 two between-subjects conditions: multifunctional product versus single-function products.

3 Half of the participants were asked to imagine that they owned an Apple iPod that  
4 included a MP3 player, a 6.0 Megapixel camera, and a GPS (multifunction condition), while the  
5 other half were asked to imagine they owned a functionally equivalent set of standalone products  
6 (i.e., a MP3 player, a 6.0 MP camera and a touchscreen GPS device; single-function condition).

7 Participants in both conditions were then presented with an upgraded multifunctional  
8 product (a newer model iPod with better camera resolution and more music storage) and were  
9 asked to state how much money they would be willing to pay for it in \$US. Participants entered  
10 their answers into a text box. No upper or lower limits were imposed.

11 Since consumers in both conditions would gain the same functional benefits from the  
12 upgrade, WTP for the upgrade should be equal across the two conditions, or perhaps even greater  
13 when upgrading from the single-function products to the new multifunctional product, since the  
14 consumer is also gaining enhanced portability by reducing the total number of devices. However,  
15 in line with our previous results, we predicted that if consumers devalue multifunctional devices,  
16 the difference between the current multifunctional product and the upgraded multifunctional  
17 should be seen as greater than an upgrade from a collection of single-function devices to a  
18 multifunctional product. Thus, WTP for the upgrade should be greater in the multifunction  
19 condition than in the single-function condition.

## 20 *Results and discussion*

21 The results indicated that WTP for the upgrade was significantly greater in the  
22 multifunction condition ( $M = \$215.5$ ,  $SD = 92.8$ ) compared to the single-function condition

1 ( $M=\$180.5$ ,  $SD= 95.9$ ),  $t(173)=2.45$   $p=.016$ ,  $d=0.37$ , even though participants in the single-  
2 function condition were potentially getting more out of the upgrade (enhanced portability).  
3 Consistent with our previous findings, these results demonstrate that functionality is discounted  
4 when it is part of a multifunctional product compared to an equivalent set of standalone products.

5 While the measures of valuation used in Experiments 1 and 2 suggest that multifunctional  
6 devices are valued less than their single-function counterparts, it remains unclear if this  
7 phenomenon would also affect replacement decisions. Past work documents a strong aversion  
8 towards waste. For example, if the functions themselves are valued less when they are part of a  
9 multifunctional device (versus single-function devices), then purchasing redundant functionality  
10 may be perceived as less wasteful for multifunctional devices, leading to greater purchase of  
11 redundant functionalities. Studies 3 and 4 examine whether consumers are indeed more likely to  
12 purchase redundant functionalities when they own a multifunctional product and whether this  
13 phenomenon is unique to electronic devices or persists in conventional low-tech products as  
14 well.

### 15 **Study 3**

16 In Experiment 3, participants were asked to imagine that they were going camping and  
17 needed to bring eating utensils. Half of the participants read they usually take a set of standalone  
18 cutlery including a knife, spoon and fork (single-function condition), while the other half read  
19 that they usually use a “dining” Swiss Army Knife, which consisted of a knife, spoon and fork  
20 (multifunction condition). In both conditions, participants read that the fork was broken and were  
21 asked to indicate how likely they would be to purchase a new Swiss Army Knife. The new  
22 Swiss Army Knife had all three utensils, thus, replacing the broken fork also meant acquiring  
23 redundant tools, namely, a redundant knife and spoon.

1            *Subjects and Design.* 232 adults were recruited from the same online platform using the  
2 same compensation as Studies 1 and 2. Individuals who participated in previous studies, those  
3 who participated more than once (based on repeating IP addresses), or those that failed to answer  
4 two manipulation checks presented at the end of the of the experiment (see SI) were disqualified  
5 ( $N=39$ ). The remaining 193 participants (56.0% male;  $M_{age}= 35.2$ ;  $SD=12.3$ ) were randomly  
6 assigned to one of two between-subjects conditions: multifunctional product versus single-  
7 function products.

8            All participants were asked to imagine a scenario in which they were going camping with  
9 friends and needed to bring utensils. Half of the participants read they usually take a set of  
10 standalone cutlery including a knife, spoon and fork (single-function condition), while the other  
11 half read that they usually use a dining Swiss Army Knife, which consisted of a knife, spoon and  
12 fork (multifunction condition). In both conditions, participants read that the fork was broken.

13            Next, all participants to indicate how likely they were to purchase a new Swiss Army  
14 knife (sold at a 40% discount for \$17.50) on a 7-point scale, between extremely unlikely and  
15 extremely likely. The new Swiss Army Knife had all three utensils, thus, replacing the broken  
16 fork also meant acquiring redundant tools, namely, a redundant knife and spoon. We predicted  
17 that consumers would be more likely to discount the remaining functionality of the  
18 multifunctional product (spoon and knife) more so than the remaining functionality in the single-  
19 function condition, and thus, would be more likely to indicate they would purchase the new  
20 Swiss Army knife in the multifunction condition than in the single-function condition.

21            *Results and discussion.* Consistent with our predictions, participants in the  
22 multifunctional condition were significantly more likely to buy a new Swiss Army Knife ( $M=$

1 5.28,  $SD=1.65$ ), compared to participants in the single-function condition ( $M=4.58$ ;  $std.=1.94$ ),  
2  $t(191)=2.69$   $p=.008$ ,  $d=0.39$ .

3 The results of Study 3 suggested that the devaluation of multifunctional products  
4 increases the likelihood of redundant purchases. However, as no standalone replacement was  
5 offered (e.g., a single fork), it is not clear whether participants in the multifunctional condition  
6 actually felt less waste aversion (Arkes, 1996; Bolton & Alba, 2012; Sun & Trudel, 2016)  
7 compared to those that owned a set of standalone items. Therefore, in our final study we  
8 examined if multifunctional product owners were likely to duplicate functions even if a  
9 standalone substitute was available.

#### 10 **Study 4**

11 The goal of study 4 was to specifically test our hypothesis that consumers are more likely  
12 to engage in redundant purchasing when they currently own multifunctional product compared to  
13 a set of single-function products. To this end we intentionally made participants' aware of their  
14 need for a specific functional capacity and asked only about their likelihood of duplicating that  
15 sole function as a single function vs. multifunctional product.

16 *Subjects and Design* 414 adults who were recruited from the same online platform using  
17 the same compensation as the previous studies. Individuals who participated in previous studies,  
18 those who participated more than once (based on repeating IP addresses), or those that failed to  
19 answer a manipulation check presented at the end of the experiment were disqualified ( $N=126$ ).  
20 The remaining 288 eligible participants (56.6% male;  $M_{age}=34.8$ ;  $SD=11.7$ ) were randomly  
21 assigned to one of three between subject conditions: multifunction, single-function, or control.

1 Participants were asked to imagine a scenario in which they were going on a vacation  
2 where they would need to use a camera. Participants in the control condition read that they  
3 owned a smartphone (including a built-in cellphone, GPS and a 10 MP camera). Participants in  
4 the multifunction condition read that they owned a smartphone (including a built-in cellphone,  
5 GPS and a 10 MP camera), but that the camera was broken (scratched lens). Participants in the  
6 single-function condition read that they owned a travel kit that originally included a separate  
7 cellphone, 10MP camera, and a GPS, but that the camera was broken (scratched lens). Thus, in  
8 both multifunctional and single-function conditions the reason the camera did not work was  
9 explicitly stated to lower the chance that participants might think that other functions were  
10 directly affected by the camera malfunction.

11 Next, participants in all conditions were then asked to imagine that they were deciding  
12 between a purchasing new smartphone (which contained a 12 MP camera) sold for \$549 or  
13 purchasing a standalone 18 MP camera sold for \$349. Thus, provided that the sole need was to  
14 replace the camera, the standalone camera was the superior option in terms of both cost and  
15 performance. Finally, participants indicated their preference for purchasing the smartphone or  
16 the camera using a binary choice response.

17 *Results and Discussion.* In line with our previous findings, participants in the  
18 multifunctional condition were significantly more likely to choose the smartphone (54.1% chose  
19 smartphone) compared to participants in the single-function condition (30.3% chose smartphone;  
20  $\chi^2(1) = 10.7, p = .001$ ). Interestingly, only 38.6% of participants in the control condition chose  
21 the smartphone, which rules out the possibility that participants with multifunctional products  
22 simply prefer to purchase other multifunctional products and indicates that the camera was  
23 indeed seen as the superior option  $\chi^2(2) = 11.4, p = .003$ .

1 Put differently, participants in the control condition chose to avoid waste and redundant  
2 functionalities (Arkes, 1996; Bolton & Alba, 2012). However, when there was a need for  
3 replacement, participants were more likely to duplicate functions when their existing possession  
4 was multifunctional versus when the same functions were contained on separate devices. This  
5 result is consistent with the hypothesis that the same functionalities are discounted when they are  
6 contained on multifunctional products versus standalone products.

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### **General Discussion**

10 Multifunctionality is often touted as the epitome of dematerialization—where once  
11 consumers needed many separate products, they can now rely on a single device to perform all  
12 tasks. Recent survey data, however, instead suggests that consumers now rely on a community of  
13 multifunctional devices rather than one multifunctional device to deliver a particular function.  
14 These costly consumption patterns may be aided by the devaluation of multifunctional products  
15 documented here. While we did not specifically test the underlining psychological mechanism,  
16 our findings suggest that the mental accounting book value of multifunctional depreciates faster  
17 than that of single use products. This phenomenon is not limited to technologic devices which  
18 might be more susceptible to perceived obsolescence (Makov, et al., 2019) but also to low-tech  
19 products like a Swiss army knife. Such hastened devaluation could lower waste aversion for  
20 multifunctional products making it less painful for consumers to purchase several devices with  
21 redundant functional capabilities and use them interchangeably.

1           In addition, the devaluation of multifunctional devices may discourage consumers from  
2 considering older multifunctional devices as reasonable substitutes for new, single-function  
3 products. Such patterns might be costly for both consumers and the environment. From an  
4 environmental perspective, reuse and repurposing are often preferable to remanufacturing or  
5 recycling since they do not require additional investment of materials and energy (Gutowski,  
6 Sahni, Boustani, & Graves, 2011). Since it is common for consumers to keep older devices home  
7 in hibernation (e.g., unused in a spare kitchen drawer; Wilson, w talk., 2017; ), designing  
8 products that highlight consumer’s ability to repurpose their retired multifunctional devices  
9 could potentially help overcome the devaluation of multifunctional products and reduce overall  
10 consumption. For example, apps that enable consumers to easily transform a smartphone into a  
11 “nanny cam” could potentially make consumers see the value still remaining in their possessions  
12 and capitalize on it.

13           Furthermore, as we show here, the devaluation of multifunctional products might  
14 discourage consumers from repairing their existing multifunctional devices and encourage them  
15 to buy new ones instead. While advocacy and legislation for the right to repair is gaining force  
16 (Bloomberg, 2017; Koebler, 2017; European Parliament, 2022) consumers’ biased evaluations  
17 might cause them to mistakenly think that their devices are not even worth repairing (Makov &  
18 Fitzpatrick, 2021; Sonogo, Echeveste, & Debaraba, 2022). Similarly, consumers may be  
19 discouraged from reselling their devices in secondary markets, or hand them in for rebates since  
20 they may assume that the transaction costs are higher than the potential gains. Thus, while  
21 smartphones today hold more computational power than the super computers used by NASA to  
22 send a man to the moon (Kaku, 2012), more often than not, once partially damaged or retired,  
23 these powerful and complex devices are often perceived as worthless by consumers.

1           Here we document how consumers may fail to appreciate the full capabilities  
2 multifunctional products using a series of hypothetical scenarios. Though this methodology  
3 allows us explore the phenomenon in isolation, it may fall short of describing the complex  
4 settings in which real life decisions take place (Kahan & Carpenter, 2017). Therefore, more  
5 research is needed to assess the extent of this phenomenon and its potential implications for  
6 sustainability. In addition to increased replacement rates, consumers misguided assumptions  
7 regarding the value of their old devices may also pose a major barrier for circular economy  
8 models that emphasize the recapture of materials and parts for reuse (Zink, et al., 2014). As one  
9 example, one ton of cellphones today contains more gold than a ton of soil from a gold mine;  
10 failure to recirculate used multifunctional devices may severely limit the ability to recapture the  
11 precious materials they contain and reduce demand for virgin materials (Wilson, et al., 2017;  
12 Glöser-Chahoud, et al., 2019). In particular, future work should directly examine how the  
13 phenomenon documented here can be overcome through improved product design, messaging  
14 and targeted economic incentives.

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